MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXVI. FEBRUARY 11, 1916. NO. 4

ANNUAL GENERAL MEETING.

Professor R. A. SAMPSON, M.A., D.Sc., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1915 was read, and is given on p. 254.

The Annual Report of the Council was partly read.

The Address was delivered by the President, after which the Gold Medal was handed to Dr. J. L. E. Dreyer, to whom it had been awarded for his contributions to Astronomical History and his Catalogues of Nebulæ (see pp. 368 to 375).

The President announced that the Council had passed the following resolution:—

"That in recognition of Mr. W. H. Wesley's faithful devotion to the interests of the Society as Assistant Secretary for the past forty-one years, the Council do present him with a donation of £250 as a testimonial of his long and meritorious service."

The presentation to Mr. Wesley of a cheque for £250 was then made by the President.

The following Amendments to the Bye-Laws, which were proposed by the Council, and of which due notice had been given to the Fellows, were put to the Meeting and carried, a slight verbal alteration having been agreed to:—

"*Bye-Law* 84. Every Fellow may at all seasonable hours inspect the Minute-books, and also the books and instruments in the Catalogue of the Library and the List of Instruments belonging to the Society, and may make extracts, drawings, and models therefrom, and may also borrow books or instruments, in accordance with the regulations annexed to these Bye-Laws. Except as aforesaid, no Fellow shall be entitled to inspect or borrow any of the papers, manuscripts, documents, or property belonging to the Society without the permission in writing of the Council or one of the Secretaries."

SECTION XXI.—INTERPRETATION.

"*Bye-Law* 86. In the construction of these Bye-Laws words denoting the masculine gender only shall include the feminine gender also."

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 376.

The thanks of the Meeting were given to the retiring Vice-Presidents and other Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Park Goff, M.A., B.C.L., F.R.G.S., Carlton Club, Pall Mall, S.W.;

François Henroteau, D. ès Sc., Detroit Observatory, Ann Arbor, Michigan, U.S.A.;

Miss Margaret Theodora Meyer, Girton College, Cambridge;

Lieut. William Robert Patterson, D.A.C., Censor's Office, B.E. Force, Quai Maritime, Boulogne, and 241 Kingston Road, Merton Park, Wimbledon, S.W.; and

Miss Mary Proctor, 5 Brunswick Square, W.C.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Miss Francisca Herschel, Observatory House, Slough, Bucks (proposed by H. H. Turner); and

Arthur Henry Phayre, 15 Warrington Crescent, W. (proposed by H. B. Adames).

Report of the Council to the Ninety-sixth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Patron	Honorary Members	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1914 December 31	1	2	240	488	48	779
Since elected	...	...	+5	+16	+3	...
Deceased	...	−1	−5	−13	−3	...
Resigned	...	...	...	−11	...	...
Since compounded	...	...	+2	− 2	...	...
Removed from list	...	...	...	−10	...	...
1915 December 31	1	1	242	468	48	760

(Four Associates are also Fellows, and are therefore counted twice in the above table.)

Mr. Knobel's Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1914 December 31 :—		
At Bankers', as per Pass-book	195 19 2	
Cheque not credited till 1915	2 2 0	
At Bankers' on Deposit	500 0 0	
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	3 17 8	
In hand of Assistant Secretary on Petty Cash Account	0 0 4	
		701 19 2
Dividends :—		
£1,250 Metropolitan 3-per-cent. Stock ...	32 3 1	
£2,000 Swansea Corporation 3½-per-cent. Stock	62 2 6	
£3,500 East Indian Railway 3-per-cent. Debenture Stock	90 0 2	
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	94 12 2	
£4,000 Midland Railway 2½-per-cent. Debenture Stock	90 4 2	
£1,000 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock	27 0 7	
£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock	64 19 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	52 3 4	
Dividend on £500 War Loan 3½-per-cent. Stock since converted	7 16 0	
£1,000 War Loan 4½-per-cent. Stock	19 2 6	
		540 3 6
Received on account of Subscriptions :—		
Arrears	181 13 0	
Annual Contributions for 1915	745 10 0	
,, ,, in advance	10 10 0	
Admission Fees	42 0 0	
First Contributions	22 1 0	
		1,001 14 0
Composition Fees		197 8 0
Sales of Publications :—		
At Society's Rooms	29 12 9	
At W. Wesley & Son's 95 1 10		
Less discount, 10 per cent. 9 10 2		
	85 11 8	
Sales of Herschel's Works : half share, received from the Royal Society	10 0 0	
Subscriptions for 3 sets of Franklin-Adams Charts	31 10 0	
Higgs' Atlas of the Solar Spectrum	3 3 0	
		159 17 5
Sales of Photographs		24 10 6
Income Tax refunded by Commissioners of Inland Revenue		45 18 9
Refunded by the Astronomer Royal on Account of Expenses of reproduction of Franklin-Adams Charts		0 11 3
Interest on Money on Deposit at Bankers' ...		0 6 6
Due to Assistant Secretary on Account of Turnor and Horrox Fund		3 7 4
		£2,675 16 5

Astronomical Society, from January 1 to December 31, 1915.

PAID.

	£ s. d.	£ s. d.
Assistant Secretary: Salary	250 0 0	
,, ,, Editing Society's Publications	50 0 0	
Clerk: Salary	100 0 0	
		400 0 0
House Duty	2 12 6	
Aircraft Insurance	9 0 0	
Servants' Insurance	0 16 0	
		12 8 6
Printing, etc.:—		
Monthly Notices	444 2 4	
Memoirs and Index	64 17 7	
List of Fellows and Miscellaneous	40 8 6	
Photo-engraving	30 2 10	
		579 11 3
Reproduction of Photographs for sale		26 18 6
Purchase of Photographs of the Solar Spectrum by the late George Higgs (negatives, etc.) ...		33 10 6
Turnor and Horrox Fund: purchase of Books for Library	15 5 0	
Binding for Library	17 16 3	
		33 1 3
Expenses of Meetings	18 16 8	
New Lantern Screen	4 0 6	
Attendance to Lantern	4 0 0	
Time-Signal: Rental of Wire	5 0 0	
		31 17 2
Subsn. to *Centralstelle für astronomische Telegramme*	1 9 6	
Telephone Subscription	6 10 0	
Registration of Telegraphic Address	1 1 0	
Postage and Telegrams	92 1 10	
Carriage of Parcels	10 7 0	
Stationery and Office expenses	10 1 7	
		121 10 11
House expenses: Allowance and sundry expenses	55 19 7	
Coal, Gas, and Electric Light	65 13 7	
Decorating Rooms	9 18 0	
Repairing Clock in Office	2 10 0	
Sundry fittings and repairs	3 17 4	
Sundries	4 7 3	
		142 5 9
Lee and Janson Fund: Grants to Mrs. McDowell		12 0 0
Supplemental Charter: Fees, etc.	102 15 6	
,, ,, Legal Expenses	11 8 2	
		114 3 8
Investments:—		
Purchase of £500 3½-per-cent. War Loan Stock, including Commission	473 9 9	
Purchase of £500 4½-per-cent. War Loan Stock, including Commission	497 6 6	
Cost of Conversion of £500 3½-per-cent. War Loan Stock to 4½-per-cent. War Loan Stock, including Commission	25 5 0	
		996 1 3
Bankers' Charges on Cheques		0 5 0
Balances, 1915 December 31:—		
At Bankers', as per Pass-book	157 8 3	
Cheques not credited till 1916	6 6 3	
In hand of Assist. Sec. on Petty Cash Account	8 8 2	
		172 2 8
		£2,675 16 5

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1915, and have certified the same to be correct. The cash in hand on 1915 December 31, including the balance at the Bank, etc., amounted to £172, 2*s.* 8*d.*

The funded property of the Society has been increased by the purchase of £1000 War Loan 4½ per cent. Stock.

The books, instruments, and other effects in the possession of the Society have been examined. The Library is in a well-ordered condition, and the Auditors note that during the past year the unbound pamphlets have been arranged in suitable cases for convenience of reference.

The instruments generally appear to be in a satisfactory state, but a few of them, especially Nos. 134 and 141 in the list, seem to be of no practical value.

A list has been laid on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(Signed) G. J. Newbegin.
H. P. Hollis.
E. Walter Maunder.

1916 *January* 6.

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1915 Jan. 1. Balance of Fund	48	19	4	1915. Grants to Mrs. McDowell	12	0	0
Dividends, East Indian Railway	10	0	9	1915 Dec. 31. Balance of Fund	47	0	1
	£59	0	1		£59	0	1

The Turnor Fund and the Horrox Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrox: to this the Society added the sum of £55 15*s.*, and the whole now stands in £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1915 Jan. 1. Balance of Fund	0	15	4	1915. Purchase of Books	15	5	0
1915. Dividends, East Indian Railway ...	17	1	0	1915 Dec. 31. Balance of Fund	2	11	4
	£17	16	4		£17	16	4

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1915 Jan. 1. Balance of Fund	25	16	5	1915 Dec. 31. Balance of Fund	35	2	5
1915. Dividends, East Indian Railway ...	9	6	0				
	£35	2	5		£35	2	5

Assets and Present Property of the Society, 1916 January 1.

	£	s.	d.	£	s.	d.
Balances, 1915 December 31 :—						
At Bankers', as per Pass-book	157	8	3			
Cheques not credited till 1916	6	6	3			
In hand of Assistant Secretary on Petty Cash Account	8	8	2			
	172	2	8			
Less due to Assistant Secretary on account of Turnor and Horrox Fund	3	7	4			
				168	15	4
Due on account of Subscriptions :—						
1 Contribution of 4 years' standing	8	8	0			
22 Contributions of 3 ,, ,, ...	138	12	0			
31 ,, 2 ,, ,, ...	130	4	0			
64 ,, 1 ,, ,, ...	134	8	0			
Other sums	12	0	0			
	423	12	0			
Less Contributions paid in advance	10	10	0			
				413	2	0
Due from Wm. Wesley & Son for sales of Publications during last quarter of 1915				14	13	5
Due for Publications supplied from Society's Rooms				25	0	0

£1,250 Metropolitan 3-per-cent. Stock.

£3,500 East Indian Railway 3-per-cent. Debenture Stock (including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (*née* Gwilt) Fund).

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock.

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,000 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£2,000 Swansea Corporation 3½-per-cent. Stock.

£1,000 War Loan 4½-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

One Gold Medal.

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.	
258.	Mars, 1909 Sept. 28. E. E. Barnard.
259.	Jupiter's Satellites VI. VII. VIII. Royal Observatory, Greenwich.
260.	Spectrum of Arcturus and Iron. Mt. Wilson Observatory.
261.	Total Solar Eclipse, 1914 Aug. 21 (3 sec.), Hernösand. A. L. Cortie.
262.	Total Solar Eclipse, 1914 Aug. 21 (25 sec.), Hernösand. A. L. Cortie.
263.	Total Solar Eclipse, 1914 Aug. 21 (5 sec.), Minsk. H. S. Jones.
264.	Total Solar Eclipse, 1914 Aug. 21 (Prominences), Minsk. H. S. Jones.
265.	Nubecula Major. Franklin-Adams Chart.
266.	Region of η *Argûs*. Franklin-Adams Chart.
267.	Southern Cross and Coal Sack. Franklin-Adams Chart.
268.	Region of α and β *Centauri*. Franklin-Adams Chart.
269.	Region of θ *Ophiuchi*. Franklin-Adams Chart.
270.	Star Cloud in *Sagittarius*. Franklin-Adams Chart.
271.	Small Star Cloud in *Sagittarius*. Franklin-Adams Chart.
272.	Nebula *h* 3501 (N.G.C. 5128). Franklin-Adams Chart.
273.	Milky Way in *Sagittarius* and *Scorpio*. Harvard College Observatory.
274.	Typical Spectra. Harvard College Observatory.

Lantern slides, 1*s*. each. Prints, mounted, 1*s*. 6*d*. each; unmounted, 1*s*. each. Postage extra.

The Award of the Gold Medal.

The Council have awarded the Society's Gold Medal to Dr. J. L. E. Dreyer, for his work on the History of Astronomy and for his Catalogues of Nebulæ. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxxv. of the *Monthly Notices* has been published.

The following parts of the *Memoirs* have also been published :—

Vol. lx. part v. P. J. Melotte: Catalogue of Star Clusters shown on Franklin-Adams Chart Plates.

Vol. lx. part vi. H. Jeffreys: Certain Hypotheses as to the Internal Structure of the Earth and Moon.

General Index to *Memoirs*, vols. xxxix. to lx.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—George Frederick Chambers.
Charles Hope Harris.
Henry Burdett Hederstedt.
George Denton Hirst.
Joshua Jukes.
Richard Kerr.
Raphael Meldola.
William Henry Stanley Monck.
Sir Andrew Noble.
William Ottway.
Ernest William Owens.
James Simms.
John Torrens Stevenson.
Henry William Lloyd Tanner.
James Francis Tennant.
Michael Foster Ward.
William Willett.
John Woodrow.

Honorary Member:—Lady Huggins.

Associates:—Carl Theodor Albrecht.
Georg Friedrich Julius Arthur Auwers.
Gilbert Defforges.

George Frederick Chambers was born on 1841 October 18, and was the only son of Richard Chambers, M.D., of Wimpole Street, and Cecilia, the youngest daughter of the Rev. A. Brodie, D.D., Vicar of Eastbourne. He was educated for the Bar, and took a considerable part in public affairs as justice of the peace, and member of several local boards, and of the East Sussex County Council and Lewisham Borough Council in turn. He was still more widely known by his writings. Many of these were digests of the laws relating to local administrations, such as county, district, and parish councils; besides numerous brochures on church and political questions of the day. He was also a frequent speaker at political meetings, and meetings connected with the Church of England. But these and many other activities, including those connected with his position as a Parliamentary barrister, did not hinder him from taking a very keen and sustained interest in astronomy. This interest he developed at an early age, and it was fostered by his uncle, Mr. Frederick Brodie, F.R.A.S., who possessed a very efficient equatorially mounted telescope in his observatory at Eastbourne. Here young Chambers made many observations of comets and eclipses, and whilst still in his nineteenth year he conceived the ambitious project of bringing out a general *Handbook of Descriptive Astronomy*. This book

which was published before he was twenty, is too well known to require description; it was exactly fitted to the needs of the small private observatory, and though there were many skilful and enthusiastic amateur astronomers in England at that time, there was no book that fully met their requirements until in August 1861 Chambers brought out his first edition, which met with complete success. A second edition was called for six years later; a third appeared in 1876; and the fourth edition, now expanded to three volumes, appeared in 1889 and 1890.

The *Handbook* was much the most considerable contribution to the literature of astronomy which Chambers made, though he also wrote a number of smaller books which found wide appreciation. *Pictorial Astronomy*, *The Story of the Comets*, *The Story of the Sun*, *The Story of the Stars*, *The Story of Eclipses*, *The Story of the Weather*, were all successful little handbooks. A more ambitious enterprise was his revision of Admiral Smyth's *Celestial Cycle*, but here he lacked the intimate practical knowledge of double-star observation and of double-star literature which could alone have rendered his work of value.

Chambers was a man of many and varied activities and interests. One to which, in later years, he devoted much energy was the collection of what may be termed tourist information in connection with total eclipses of the Sun, and he was pursuing such inquiries with respect to the eclipse of 1916 February 3 at the time of his death. As an astronomical observer his chief interest lay in the field of coloured stars, and he brought out two or three catalogues of red stars, besides acting for four years as Director of the Coloured Star Section of the British Astronomical Association, of which he had been a leading member from its foundation.

Mr. Chambers died on 1915 May 24, in the seventy-fourth year of his age, leaving a widow and five daughters.

He was elected a Fellow of the Society 1864 February 12.

E. W. M.

Charles Hope Harris was born at Clare, Suffolk, in 1846. He was the son of a Congregational minister who migrated to South Australia with his family in 1851. At an early age he entered the service of the Survey Department of South Australia, with which he remained closely connected for half a century. He took a prominent part in the survey work connected with the early development of the State, and in later years was recognised as a leading authority in his profession. In 1874 he was entrusted with the trigonometrical survey of the region north-west of Port Augusta, and three years later discovered Lake Harris, which was named after him by Governor Musgrave. At a later date, Mount Harris was named after him "as an offering of regard and esteem" by the explorer Tietkens. He was one of the founders of the South Australian branch of the Royal Geographical Society, and was the author of numerous papers on astronomy, geodesy, and geography published by that and other learned

societies. In geography he was keenly interested in the subject of nomenclature, and did much to preserve native names on the new maps of the State. The *Handbook for Government Surveyors* for use in South Australia was compiled by him, as was also a still unpublished work on "Geodesy and Practical Astronomy," embodying many examples gathered together during his long experience in the field. The subject of terrestrial magnetism also had a strong attraction for him, and he made many useful observations in this connection. He was vice-president of the Institute of Surveyors for many years in succession, and was also a valued member of the South Australian Astronomical Society and other scientific bodies.

For the last fifteen years of his life he was blind, but in spite of this misfortune he continued to work with success. With the aid of a ruler to keep his lines straight, he was still able to write quite legibly. His widow and his son (Mr. H. P. Harris), however, spared him much unnecessary labour by acting as amanuenses, and through their devotion in reading to him he was kept well informed as to the progress of science. He was of a kindly and lovable disposition, and was greatly esteemed by all who knew him. He died at Adelaide on 1915 June 26.

He was elected a Fellow of the Society 1910 January 14.

[For the above particulars of his life the Council are indebted to Mr. G. F. Dodwell of Adelaide.]

Henry Burdett Hederstedt was of Swedish origin, and was born at Southampton in 1833. He was educated in Scotland, and adopted civil engineering as his profession.

He assisted his brother-in-law, the late Sir Rowland Macdonald Stephenson, in survey work connected with projected railways in Asiatic Turkey, and was afterwards engaged on the construction of the Madras railways. Subsequently, for about twenty years, he was chief engineer of the Oudh and Rohilcund Railway. Of the many important works which he carried out in India, the most remarkable was the great Dufferin Bridge across the Ganges at Benares, connecting the Oudh and Rohilcund Railway with the East Indian Railway. In commemoration of this signally successful work, Sir R. M. Stephenson presented him, in 1877, with an interesting planetarium, which was reputed to have once been the property of King George the Third. A photograph of this instrument has been deposited in the library by his executrix.

Mr. Hederstedt was unmarried, and led a most retired life, in the full enjoyment of the numerous scientific instruments and books which he possessed. He was lavishly generous, so far as his means admitted, to all who appealed to him for assistance. He was a Member of the Institution of Civil Engineers, and also of the Society of Arts.

He died at his residence, Twyford Lodge, Bickley, Kent, on April 29, in his eighty-second year.

He was elected a Fellow of the Society 1878 February 8.

George Denton Hirst was born at Redfern, Sydney, on 1846 April 7. In business he was a wine and spirit merchant, and his principal hobby was astronomy, for which he maintained a keen interest for over forty years. Besides the observing work he did, his advice and practical help were always available to those in difficulties, and often on Sunday mornings a small gathering of amateurs met at his home and criticised each other's observations. In 1874 he observed the Transit of Venus at Woodford, New South Wales, and his report was published in the *Memoirs R.A.S.*, vol. xlvii. As an astronomical draughtsman Mr. Hirst had no equal in Australia. His drawings of Mars were marked by the same skill and delicacy as those of N. E. Green of England. His papers on Mars and Jupiter, accompanied by drawings, are published in the *Journal of the Royal Society of N.S.W.*, vols. x. and xiv. To the British Astronomical Association he contributed papers on double stars, wiring of astronomical instruments, and on astronomical drawing, as well as observations and sketches of Mars and Jupiter. To the Royal Astronomical Society he contributed a useful list of measures of southern double stars (*Monthly Notices*, vol. lxx.). A long series of fine drawings of Jupiter which he made in 1876 and 1878 were presented by him to the Society and are deposited in the library. He became a member of the Royal Society of N.S.W. in 1876 and of the British Astronomical Association in 1895, and was at one time President of the N.S.W. branch of the latter.

In his young days he was an enthusiastic yachtsman, and also took great interest in work with the microscope and with the lathe. During the last twenty years of his life he lived at Mosman, Sydney, and died there on 1915 May 20. He is survived by a widow, a daughter, and a son. By his death amateur astronomy in New South Wales has lost one of its ablest supporters.

He was elected a Fellow of the Society on 1895 March 8.

Joshua Jukes, only surviving son of the late Rev. Richard Jukes, the well-known Primitive Methodist travelling preacher, died at Aberdovey on 1915 March 6, at the age of seventy-six.

A native of Staffordshire, he resided for many years in the Birmingham district, but on account of failing health moved into Wales, where he spent the last twenty years of his life.

Mr. Jukes was by trade a printer, but his chief interest in life consisted of his study of Nature. He was of a thoughtful and retiring disposition, his favourite companions being his books, but he was greatly respected by all with whom he came in contact. Like his father, he wrote several poems of a religious nature.

He was married in 1884, and leaves a widow and one son.

He was elected a Fellow of the Society on 1894 January 12.

Richard Kerr was born in Ireland, but took up residence in this country when a young man. He early manifested a love of natural history and science, and this tendency was carefully

fostered by his father, who took every opportunity to encourage and to instruct.

After passing through a short course at St. Luke's Training College, Exeter, he entered upon educational work at Folkestone, where he obtained a considerable reputation as visiting tutor to schools and colleges. Whilst residing at Folkestone he became closely identified with the social and scientific life of the town, frequently placing his conspicuous powers as a lecturer at the disposal of charitable and educational organisations without fee or reward except the pleasure he always experienced in doing good.

Mr. Kerr came to London some twenty-two years ago, at the time when his increasing reputation as an exponent of popular science led him to adopt this as his profession and to abandon his scholastic work. He left Folkestone amid many regrets, for he parted from friends who valued him highly. During his residence he did much for the town. In addition to his duties as a teacher, he founded the local microscopical society, of which he was an active member; he also took part in the management of the museum, and was a member of the School Board. He was an artist of marked ability both in oils and in water-colours. His large picture in oils, "Old Folkestone," was secured by the Town Council, and forms a striking record of the earlier aspect of the town.

In the early days of the "X" rays and wireless telegraphy he was one of the first to introduce them to the public in lecture form with practical demonstrations; yet perhaps his most appreciated subjects were astronomy and microscopy, illustrated, as they always were, by copious lantern projections. All sorts and conditions of men attended his lectures, and it is not too much to say that he pleased them all. In recent years he was among those appointed by the Home Office to lecture to the inmates of His Majesty's prisons.

He was the author of several books which attained considerable popularity, and for many years was a Fellow of the Geological Society. He enjoyed the friendship of many eminent men of science, to whom he used frequently to express his indebtedness.

The strain of constant travelling seriously affected his health, which had been failing for some years, and during this period he suffered much. Early in May his condition became much worse, and he passed away at his residence at Mitcham on May 19, aged sixty-five years, leaving a widow and a family of four. His many friends will remember him as a great and generous nature—always considering others rather than himself, and ever ready to do a service or a kindness.

He was elected a Fellow of the Society 1903 January 9.

[The Council are indebted for this notice to his friend Mr. C. W. Raffety.]

Raphael Meldola was born in London on 1849 July 19, and was the only son of the late Samuel Meldola. He came of an ancient Sephardic family, the Sephardis being Spanish and

Portuguese Jews. This family trace their descent without a break from Isaiah Meldola, who died at Toledo A.D. 1340. The family seem to have migrated to Italy, where they produced a long line of scholars and men of science, including some who were chief Rabbis.

Professor Meldola received his early education at Northwick College, Maida Hill, under the late Rev. A. P. Mendes. In 1866 he entered the Royal College of Chemistry, then under Professor Frankland. Here he laid the foundation of that wide chemical knowledge which he developed so eminently in later life. After leaving the college he worked for some time in the research laboratory of the late Dr. Stenhouse. In 1870 he first turned his attention to the coal-tar colour industry by becoming an assistant in the laboratory of the colour works of Messrs. Dower of Brantford, where he remained for two years. In 1873 he became assistant and demonstrator to Professor Frankland at the Royal College of Chemistry, and afterwards he joined Sir Norman Lockyer as assistant in the Solar Physics Laboratory. In 1875 Professor Meldola was sent out with the British Expedition to observe the solar eclipse of that year at the Nicobar Islands. Here in company with Dr. H. W. Vogel he joined the party from India under Captain (now General) Waterhouse, which was stationed at Carnorta. Meldola had charge of the quartz telespectroscope, but bad weather prevented any observations being made. In 1877 he became scientific chemist at the aniline colour works of Messrs. Brooke, Simpson & Spiller, where he remained for eight years. Here he developed considerable activity in important researches on coal-tar products, and he communicated many valuable papers to the Chemical Society. Unfortunately the best use was not made of some of his discoveries, which were taken hold of and developed in the large colour industries in Germany. In 1885 Meldola was appointed Professor of Chemistry at the Technical College, Finsbury, a position which he held to the day of his death. Many distinguished chemists at the present day owe their knowledge to the excellent instruction they received at Finsbury. Meldola's high position as a chemist has been fully recognised. In 1895 he was President of the Chemical Section of the British Association. He was President of the Chemical Society (1905-7), of the Society of Dyers and Colourists (1907-8), of the Society of Chemical Industry (1908-9), and of the Institute of Chemistry (1912-15).

Meldola's interests were not confined to chemistry; natural history was his first love, and engaged his attention hand in hand with chemistry throughout his life. His first scientific papers, published in 1868, were on entomological questions; and some years later he was encouraged in his biological researches by Charles Darwin, whom he visited at Downe. Darwin suggested to Meldola the importance of a translation of Weismann's *Studies in the Theory of Descent*, which he eventually published, enriched by his editorial notes, and by the preface written by Darwin.

In 1896 he became President of the Entomological Society of London, and in 1910 he delivered the Herbert Spencer lecture at Oxford on "Evolution, Darwinian and Spencerian."

Professor Meldola's contributions to science embrace numerous papers on chemical and biological subjects, besides some independent works, among which his lectures on the chemistry of photography may be mentioned, in which the action of light on a haloid salt of silver is attributed to an oxidation. In 1878 the announcement of Dr. Henry Draper's discovery of oxygen in the sun led Meldola to publish two papers "On a Cause for the Appearance of Bright Lines in the Solar Spectrum," and on "Oxygen in the Sun." It does not appear that he published any other papers on astronomy.

Meldola occupied a unique position from "the diverse interests that had appealed throughout his life to his many-sided intellect." He was thus brought into contact with many men of eminence in various branches of science, and his wise and sensible advice was sought after. Indeed, one of the conspicuous features of Meldola's character was a rare common sense, which does not always accompany high scientific ability. At Finsbury he was "invaluable to his colleagues as a wise adviser, and a steady, constant, and loyal colleague." By nature he was a most amiable man, modest and undemonstrative in demeanour, clear in his judgment, and full of tact.

At the outbreak of the war Meldola was appointed chairman of the Advisory Council to the Government on the British Dyes Company; and he took a very active part in researches for the production in this country of optical and other glasses.

Professor Meldola was elected a Fellow of the Royal Society in 1886, and in 1913 he was awarded the Davy Medal. He received honorary degrees of D.Sc. from Oxford and LL.D. from St. Andrews. For two years he was Examiner for the Natural Sciences Tripos at Cambridge. In 1897 he received the Jubilee Medal from the Queen.

Professor Meldola died quite suddenly on 1915 November 16. A remarkable meeting of the Maccabean Society, of which he had been President since 1911, was held on December 15, which was presided over by Lord Reading and attended by several eminent men of science, when addresses were delivered in tribute to the great scientific work he accomplished in his life.

He was elected a Fellow of the Society 1877 March 9.

E. B. K.

William Henry Stanley Monck was born on 1839 April 21. He was the third son of the Rev. Thomas Stanley Monck, Rector of Innistiogue, County Kilkenny, and was grand-nephew of the first Lord Monck. Except for the help of tutors for a short time at his father's house, he seems to have been to a great extent self-educated, but notwithstanding this initial educational disadvantage he had a distinguished career in Trinity College, Dublin. There

he obtained first place in the University science scholarship examination in 1861. Later in the same year he won the first senior moderatorship and gold medal in ethics and logics. He also won the Wray Prize in metaphysics, and in the following year the Elrington Theological Prize was awarded to him for an essay on the subject, "'Canst thou by searching find out God? Canst thou find out the Almighty unto perfection' (Job xi. 7): to be discussed with reference to the limits of religious knowledge." In 1864 he took out his divinity testimonium, being placed in the first class at the final divinity examination, and won the first theological exhibition. He obtained fellowship prizes at the examinations of 1867 and 1868, but failed to win a fellowship. In 1878 he was appointed Professor of Moral Philosophy, a post which he held until 1882. He was the author of a number of works on logics and metaphysics, including *Space and Vision*, *An Introduction to the Critical Philosophy*, *An Introduction to Logic*, and *Sir William Hamilton* in English Philosophers Series.

In 1875 he was called to the Bar, and subsequently became Chief Registrar in the Bankruptcy Division of the High Court of Ireland, a post which he held for many years.

Monck was well known as an original writer on astronomical subjects, his contributions being always marked by sound reasoning, good sense, and moderation. A collection of his articles, which had for the most part appeared in *Popular Astronomy*, was published in book form in 1899, under the title *An Introduction to Stellar Astronomy*. He also contributed a number of letters to *The Observatory* magazine, dealing chiefly with the maintenance of the Sun's heat, historical eclipses, and chronology generally. He also wrote frequently for *The English Mechanic* and other papers. In 1890 he took an active part in the foundation of the British Astronomical Association. He was a member of the first Council elected by that association, and contributed many interesting and important papers to its Journal.

In 1892, in the *Publications of the Astronomical Society of the Pacific*, vol. iv. p. 98, he drew attention to the relation existing between the proper motions of stars and their spectral types. In the following year he dealt with the subject again in *Astronomy and Astrophysics*, vols. xi. and xii., where he showed that stars of Type II. have on the average larger proper motions than those of Type I. The importance of this discovery, corroborated as it has been by the later researches of Kapteyn, Dyson, and others, has been recognised by Professor Eddington in his book on *Stellar Movements and the Structure of the Universe*. In 1898 another paper on this subject from his pen appeared in *The Astrophysical Journal*, vol. viii. p. 28. Later he returned once more to the subject in the *Publications of A.S.P.*, vol. ix. p. 123; and from a discussion of the Dunsink Catalogue of 717 stars (mostly with large proper motions) and the Pulkova Catalogue of stars having an annual motion in Declination of over 0″·1, he demonstrated that the earlier types of stars are endowed with a smaller proper

motion than the later. In this paper he discussed the relative frequency with which stars of different types occur in space, and was led to the interesting conclusion that, although the Sirian stars in the Draper Catalogue exceed in numbers the Capellan stars in the proportion of about $2\frac{1}{2}$ to 1, yet the latter are really the more numerous, and that their apparent numerical inferiority is a delusive appearance arising from their smaller luminosity; and went on to point out the importance of keeping this fact in view in speculations relative to the structure of the Galaxy, where in consequence of distance the apparent preponderance of Sirian stars may be due to the fact that they still remain distinctly visible when the light of their Capellan companions is too faint to enable them to be observed separately.

The General Index to the *Publications of A.S.P.* contains references to a number of interesting and suggestive articles by Monck on "The Sun's Motion in Space," "The Radiant Points of Meteors," and other subjects, which are marked by the critical acumen, close reasoning, and originality which distinguish all his work.

He was quiet and reserved in manner, living a rather retired life amongst his books. He had also a considerable reputation as a chess-player. He died on 1915 June 24, leaving no children. His widow, who was daughter of Mr. Tobias Peyton, of the County Roscommon, survived him only a few months.

He was elected a Fellow of the Society 1886 April 9.

A. A. R.

Sir Andrew Noble was born at Greenock on 1831 September 13, and was educated at the Edinburgh Academy and the Royal Military Academy, Woolwich. He took special interest in the science of gunnery, and joined the Royal Artillery when 17 years of age. Rapid promotion followed, and he became a captain in 1855. For a short time he was associated with Sir Edward Sabine on the magnetic survey at the Cape, and in 1857 became secretary of the Royal Artillery Institution. In 1859 he was Assistant Inspector of Artillery, and about this time was appointed member of several important Government Committees dealing with ordnance and explosives. A year later, while continuing to take an active part in the work of these committees, he joined the great works at Elswick as director of the ordnance department. In conjunction with Lord Armstrong he there carried out a multitude of investigations of first-rate importance. Among his inventions was a "chronoscope" which made it possible to measure a millionth of a second with ease, and this instrument was effectively employed in connection with problems relating to the passage of a shell from a state of rest to the mouth of a gun. During many years he also collaborated in important researches on explosives with Sir Frederick Abel and Sir James Dewar. Eventually he became Chairman and Managing Director of the Elswick firm.

He was a member of the Executive Committee of the National Physical Laboratory, and took a great interest in the work of this institution.

His invaluable services to science and to his country received due recognition. He was elected a Fellow of the Royal Society in 1870 and was awarded a Royal Medal in 1880. He was made a C.B. in 1881, K.C.B. in 1893, and created a baronet in 1902. He was also the recipient of numerous other distinctions at home and abroad. He died on October 22 at his residence in Argyllshire.

He was a Fellow of the Society for more than sixty years, having been elected in 1854 June 9.

William Ottway was born in Clerkenwell, 1848 October 14. He came of a family long associated with the manufacture of optical instruments, for theodolites made by his father, who was established in Carey Street early in the nineteenth century, are in use at the present day; and as far back as 1640 the family appears to have been established near the Royal Exchange in the scientific instrument trade. While still a young man he became manager to J. Hammersley & Co., Islington, then probably the largest wholesale manufacturing opticians in the country, and of which firm it was said "that it did not matter what retail firm obtained a contract for optical work, the instruments would eventually be found under manufacture at the Islington works." Whilst here he became acquainted with the late Dr. Common, an acquaintance which eventually led to business partnership and has left a lasting mark on the design and methods of construction of some of the more important instruments used in modern astronomy and gun-sighting, notably large reflectors, cœlostats, and gun-sighting telescopes. Some of these earlier designs marked a new era in the mounting of astronomical instruments, though they have been condemned for their mechanical defects. Ottway, however, with a keen sense of their shortcomings, always complained privately of being compelled to manufacture mechanically defective instruments through the parsimony of the buyers. It may be noted that he was closely connected with the design and construction of Common's 36-inch and 60-inch reflectors, the 36-inch reflector at Cambridge, and the 30-inch reflector now at Sir Norman Lockyer's Observatory at Sidmouth. He was also closely associated with Mr. Calver in the construction of reflecting telescopes for upwards of forty years. A valuable contrivance for photographic equatorials, which he modified and made really workable, was the Russell electrical control for the driving clock, the simple form with a ratchet and toothed wheel being his design.

Towards 1890 Dr. Common turned his attention to the use of telescopes for gun-sighting, and sought Ottway's aid to put his ideas into practical form. Some of the earliest telescopes thus made were used on active service with the naval guns in

the Boer war, and eventually gun-sighting telescopes formed part of the equipment of all naval guns. In consequence of the rapidly increasing demand for this kind of instrument, Common decided to build the large optical factory at Ealing, and in commemoration of his research on the nebula in Orion the works were named "Orion Works," and Ottway became Common's sole partner. Gun sights continued to be made in large numbers, and those used during the naval engagements of the Japanese and Russian squadrons were all made at the Ealing works.

On Dr. Common's death in 1903 Ottway was left to carry on the business alone, but he did this so successfully that it was necessary to enlarge the works from time to time; he further developed the gun sight and made an improved telescope of variable power which is now used throughout the navy, and adds in no small measure to the efficiency of our naval guns.

During his residence in Ealing he took an active part in the municipal work of the borough, and had been a member of the Ealing Town Council just over seven years. But for his untimely death, which took place on 1915 January 1, he would have occupied the mayoral chair, having been nominated to that office.

He leaves a widow and four sons.

He was elected a Fellow of the Society 1906 January 12.

[The Council are indebted for this notice to Mr. W. Shackleton.]

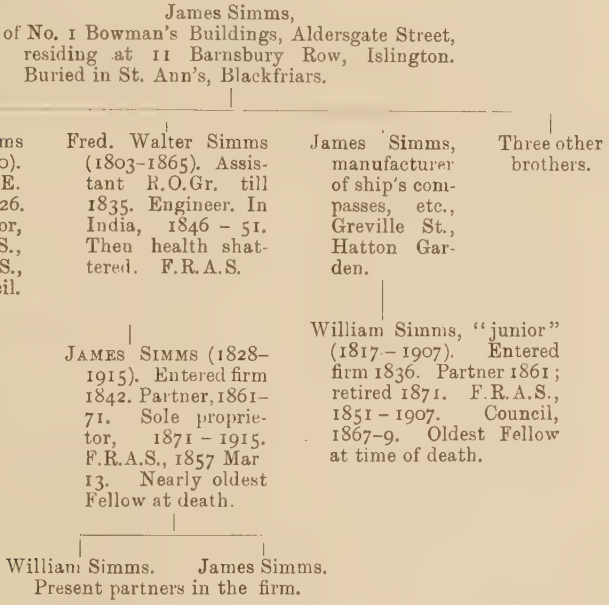
Ernest William Owens was born in 1854, and went to sea as an apprentice when he was 14 years of age. He qualified as second mate in 1872, and steadily advanced to the rank of captain. After a varied and adventurous career in numerous sailing vessels and steamships, he was appointed in 1893 to an instructorship at the Liverpool Technical College. Five years later he came to London to take up the position of junior examiner of masters and mates for the port. He eventually rose to be chief examiner, and was also secretary to the Local Marine Board, London. He took great practical interest in everything connected with the merchant service, and was widely known and highly respected. Several acts of conspicuous bravery are recorded of him, and on one occasion he was honoured by the award of the Albert Medal "for gallantry at sea."

Captain Owens was keenly interested in astronomy, and was very successful as a writer of nautical text-books, one of his best-known volumes being *How to learn Ashore the Rule of the Road at Sea.* He died suddenly at his residence at Erith on 1915 August 14.

He was elected a Fellow of the Society 1903 May 8.

James Simms, who died on September 4, at the age of eighty-seven, was nearly, but not quite, our oldest Fellow. Since 1871 he has been sole proprietor of the business well known by the name of "Troughton & Simms," now being carried on by his sons

William and James Simms. There has been no Troughton in the business since Edward Troughton retired from it in 1831. The leading facts about the firm were given in the *Monthly Notices*, lxvii. p. 237, on the occasion of the death of Mr. William Simms, who was partner with the subject of this note from 1861 to 1871, and have recently been recalled with some additions in the *Observatory* for 1915 December. They need scarcely be repeated at length; but it may be of general interest to have a brief summary in the form of a genealogical tree, in so far as it relates to the various members of the Simms family who had astronomical leanings. The frequent use of the names James and William carries with it some risk of confusion.


James Simms,
of No. 1 Bowman's Buildings, Aldersgate Street,
residing at 11 Barnsbury Row, Islington.
Buried in St. Ann's, Blackfriars.
William Simms (1793 – 1860). Partner of E. Troughton, 1826. Sole proprietor, 1831. F.R.S., 1852. F.R.A.S., 1831. Council.
Fred. Walter Simms (1803–1865). Assistant R.O.Gr. till 1835. Engineer. In India, 1846 – 51. Then health shattered. F.R.A.S.
James Simms, manufacturer of ship's compasses, etc., Greville St., Hatton Garden.
Three other brothers.
W. H. Simms. See note (α).
James Simms (1828–1915). Entered firm 1842. Partner, 1861–71. Sole proprietor, 1871 – 1915. F.R.A.S., 1857 Mar 13. Nearly oldest Fellow at death.
William Simms, "junior" (1817 – 1907). Entered firm 1836. Partner 1861; retired 1871. F.R.A.S., 1851 – 1907. Council, 1867–9. Oldest Fellow at time of death.
William Simms.
James Simms.
Present partners in the firm.

(α) Mr. W. H. Simms was apparently never a F.R.A.S., for which one reason was probably that he resided for some years in Ceylon. But our volumes contain several papers by him; those in *M.N.*, vi. 206, vii. 20, xvii. 27 being "communicated" by his father. In xvii. 176 the ceremonial "communication" is omitted from the title, but there is no justification of this by a recorded election as a Fellow. The abstract indexed to him (Gen. Index) in xvii. 28 is really by Hartnup; and that in xvii. 80 is apparently by mistake for his father. Finally, the index refers rightly to a "Notice of his papers, etc.," in xvii. 9; but in the notice itself he is erroneously described as "W. Simms, Jun^{r}," a designation generally used for another member of the family.

(β) For those members of the family who were F.R.A.S., further particulars are given in the obituary notices.

"Soon after taking command Mr. James Simms, finding that the premises in Fleet Street were becoming too small for the fast-

increasing business, purchased two acres of land in Woolwich Road, Charlton, Kent, which are now practically covered with workshops, the firm still continuing to have a shop in Fleet Street (now No. 138; formerly numbered 136), and from these works in Charlton instruments have issued to observatories in all parts of the world. The records of the firm show that Transit Circles have been supplied to ten observatories of the first class: Harvard, Dunecht, Cambridge, Melbourne, Perth (West Australia), Pola (Austria), Mexico, Sydney, Canada, and the Cape of Good Hope. The optical parts of the Greenwich Transit Circle and of the former Great Equatorial were made by the firm, but these were in the early years of Mr. James Simms, and can scarcely be said to have been made under his direction. The present Altazimuth was, however, his creation, as were all the micrometers now in use at Greenwich for measuring photographs, and many other instruments of the class now located in various parts of the world. Equatorials have been made in some number, and many of the instruments used in the Transit of Venus Expedition of 1874, some of which have found a home in British and Colonial observatories, were made by the firm." (*Observatory*, 1915 Dec.)

In this more specially scientific part of the work Mr. James Simms took a keen delight. When the present writer took up his duties in Oxford in 1894, he had the pleasure of a visit of a few days from Mr. Simms, and gratefully remembers the varied benefits to the Observatory which resulted therefrom. Among the more important and enduring are, firstly, the "Artificial Sky," an apparatus whereby stellar transits can be observed by students independently of weather, and wherein lightness and strength are ingeniously combined by the use of bamboo rods and wire-stays; and, secondly, a simple type of micrometer for measuring photographic plates, which has been adopted, with very slight modifications, in all the Oxford instruments and in several copied from them elsewhere. But minor matters were even more striking. There was at that time something wrong with the transit circle, the cause of which Mr. Simms identified with admirable quickness. And in another instrument there was a defect for which he wanted a special tool not in the observatory workshop: without a moment's hesitation he took off his almost clerical frock-coat, first made the tool, and then with it made the necessary repair, all with the obvious zest of a boy enjoying a holiday.

Visitors to his works at Charlton often found him testing theodolites in the open yard; for the specially scientific work was only a minor portion of the activities of the firm. Theodolites, sextants, and surveying instruments were made in large numbers and supplied to all parts of the world; and Mr. Simms reserved for himself the pleasure of testing the optical performance of each. But he was always ready to leave this engrossing occupation to pilot the visitor round the works, dwelling lovingly at any point where some new scientific experiment was being made; and it was seldom indeed that there was not something of the kind. He

made a special form of surveying theodolite called a tacheometer, which was in great request in some foreign countries; and he introduced reading microscopes in place of verniers, whereby the accuracy of theodolite observations was very considerably increased.

"Accurate division is a speciality of the establishment, and the British National Standards are the work of Messrs. Troughton & Simms. Not very many years ago Mr. James Simms was asked to construct the National Standards for the Russian Government, and his completion of the task was so satisfactory that the Czar of Russia presented him with a service of gold plate as a personal gift in recognition of the service rendered—an incident of which Mr. Simms was very justly proud." (*Observatory*, *loc. cit.*)

There is but one paper in our *Monthly Notices* by James Simms, "Description of a Zenith Telescope," which was also exhibited at the meeting of 1868 March 13. It was for use by what is known as "Talcott's method," from the description given by Talcott in the U.S. Coast Survey Report for 1857. But with characteristic thoroughness Mr. Simms, after tersely describing the instrument itself and the method, points out that the method was used by Pond and described by him in a paper read to the Royal Society 1834 March 13, which "paper appears to have been generally lost sight of." It seems probable that James Simms owed knowledge of Pond's work and paper to his uncle F. W. Simms, who was assistant to Pond till 1835 (see tabular statement). His own paper of 1868 March seems to have elicited from Professor Piazzi Smyth at the following meeting two extracts from letters by G. Davidson, describing the instruments used in the U.S. Coast Survey; but no further reference is made to Pond's prior claims.

Mr. Simms married in 1859 June, and leaves two sons, William and James, who are now carrying on the business as partners, and who kindly supplied some of the information quoted above. Mrs. Simms died some years before her husband.

He was elected a Fellow of the Society on 1857 March 13.

H. H. T.

Henry William Lloyd Tanner, who died 1915 March 5, was born at Burham, in Kent, 1851 January 17. He was educated at Bristol Grammar School and Jesus College, Oxford. His decided bent for mathematical research was stimulated by Mr. John Griffiths, his mathematical tutor. He held educational appointments until the year 1883, when he was appointed Professor of Mathematics and Astronomy in the newly founded University College of South Wales and Monmouthshire at Cardiff. He occupied this chair till his resignation, through failing health, in 1909. He took an active part in arranging the mathematical work of the University, and made a great reputation for himself as an administrator and inspiring teacher. When the British Association met in Cardiff in 1891 he was one of the local secretaries. Such a position is most difficult to fill satisfactorily,

but Professor Tanner was thoroughly equal to it, and did much to make the meeting the brilliant success it was. In science he will be remembered for valuable researches in the theory of partial differential equations and in some of the most abstruse branches of the theory of numbers. In the recondite theory of the multisection of the roots of unity he made a considerable advance, and showed that, while having a thorough grasp of the principles, he could express himself to his mathematical readers with lucidity and elegance.

He became a Fellow of the R.A.S. on 1890 January 10, and was made a Fellow of the Royal Society in 1899. His researches will be found for the most part in the *Proceedings of the London Mathematical Society.* P. A. M.

Lieutenant-General James Francis Tennant at the time of his death was almost our oldest Fellow, and, though probably scarcely known to the majority of present Fellows, formerly took an active part in the proceedings, contributed many papers, served on the Council, and was President of the Society. The activities of General Tennant's life were those of a geodesist, a soldier, an astronomer, and a Government official, and as these were somewhat intermingled, it will be desirable to give a brief sketch of his career chronologically.

James F. Tennant was born at Calcutta on 1829 January 10, He was of Scotch origin, and was the eldest son of Brigadier-General Sir James Tennant, K.C.B., of the Bengal Artillery, and of Elizabeth, daughter of Charles Pattinson, Esq. He received his education at private schools and at Addiscombe College, the military seminary of the East India Company, from which he passed out with distinction in mathematics in June 1847, and landed at Calcutta as Second Lieutenant in the Bengal Engineers in March 1849. He was at once attached to the Trigonometrical Survey, and joined the party of Captain Strange, who had just then taken over the triangulation of the Western Section of the Great Longitudinal Series from the Sironj base to Karachi. Those who know the scheme of the geodesy of India will recognise this as half of the great span of triangulation which crosses the base of the peninsula, east to west, from Calcutta to Karachi. This work was arduous and beset with much difficulty, and Karachi was not reached until May 1853, and here it was arranged to measure another base to complete the series. This was done by January 1855, and Lieutenant Tennant took a prominent part in the work, being specially entrusted with the levelling operations and the determination of the latitude of Karachi. During this period Tennant married Miss Augusta Dick, by whom he had three sons and one daughter. He was next transferred to the triangulation of the Meridional Series, and held responsible positions, which it is unnecessary to specify in detail. He left the work of the Survey owing to the outbreak of the Mutiny in 1857. In the summer of that memorable year, Lieutenant Tennant,

being on leave, went unofficially to Delhi to watch the course of events, and the Royal Engineers being short of officers, he was kept to serve. It is related in Kaye and Malleson's *History of the Mutiny* that in the assault on Delhi on September 12, to the fourth column was assigned the task of entering the Lahor Gate, and the Engineer officers attached to this column were Lieutenants Maunsell and Tennant. With other officers of the Survey he remained for a time with the fighting forces, and was attached as Garrison Engineer at the siege of Lucknow, being mentioned by General Outram as one of the officers deserving honourable mention.

Tennant then returned to his work on the Survey, but only for a short time. In April 1858, Captain Jacob, the Director of the Madras Observatory, was obliged to return to England (for the second time) owing to ill-health, and Major Worster of the Madras Artillery took temporary charge. On 1859 October 13, Major Worster relinquished the duties to Tennant (now Major), who was temporary Director of the Madras Observatory until October 1860, when Mr. Pogson was appointed astronomer.

It is difficult to trace precisely the incidents of his professional life in the next seven years, but in this period he was occupied in the Public Works Departments in Burma, Bengal, and Madras. His first wife died in 1859, and he married again in 1867, his second wife being Miss Selina Tudor Crawford. A sentence in Sir Clements Markham's *Memoir of the Indian Surveys*, in which Tennant's name is mentioned not infrequently, seems to imply that he took no part in the Trigonometrical Survey in these years. There is one communication only by him to the Royal Astronomical Society about this time, that being on the correction of an error of sextants, and is addressed in 1865 from Akyab, a seaport on the coast of Burma; but his name was soon after brought prominently before the astronomical world in connection with the Solar Eclipse of 1868 August 17–18, which was seen Total from a track across the Indian peninsula. Tennant called attention on January 1867 to the importance of observing this eclipse scientifically. He received the support and help of the Astronomer Royal, and of the Government of India, who supplied the necessary funds, and Major Tennant, with Lieutenant John Herschel and other officers, observed the eclipse from a station near Guntoor.

This eclipse will be alluded to later. In May 1869 Tennant began to make suggestions for observation of the eclipse of 1871 December 11–12, which would also be seen Total from Southern India. Subsequently he was entrusted by the Government with the organisation of the observations of this phenomenon, and he himself observed at Dodabetta with much success. In 1872 Sir George Airy called upon him for help in arranging for observation in India of the Transit of Venus of 1874. The British Association had passed a resolution asking the Government of India to provide instruments and undertake the observation of the Transit, and, armed with this resolution and the authority of

the Astronomer Royal, Tennant addressed the Secretary of State, and after some delay obtained the necessary instruments with the proviso that these were to be eventually transferred to some solar observatory. Colonel Tennant selected Roorkee, a place to which, as he says, he was called by other duty, as his main station, and at once set about building piers, making domes, and preparing observers, these being for Roorkee, besides Tennant who used the Equatorial, Captain Campbell, and Captain Waterhouse, I.S.C., from the Surveyor-General's office at Calcutta. The latter was in charge of the photographic observations, helped by one of his own assistants and two men of the 55th Regiment, trained by Colonel Tennant. Wet collodion plates were used, and the results were pronounced to be excellent. Captain George Strahan observed the Transit at Lahore, and Mr. Hennessey at Mussooree, but not under Colonel Tennant's superintendence. Nevertheless he reduced their observations for comparison, and gave an account of the operations at the three stations in a report published by the Office of Government printing in Calcutta in 1877.

The preface to this report is addressed from H.M.'s Mint, Calcutta, for Colonel Tennant had been appointed Master of Her Majesty's Mint on 1876 January 18, an office that he had previously filled temporarily on various occasions.* He held this post until 1882 February 6, when he retired and came home to England. The writer of this notice well remembers a visit he paid to Greenwich soon after his arrival. Time had made some changes in his outward appearance on which those who knew him ten years earlier could scarcely refrain from comment, but he was full of vigour and eager with proposals for schemes for work to be initiated and carried out during his retirement. Remembering his practical knowledge of photography, it is not surprising that he was chosen as one of the British delegates at the Astrographic Conference held at Paris in 1887. He was elected to the Council of the Royal Astronomical Society in 1885, and was chosen as President in 1890 and 1891. He filled that position with dignity, tact, and judgment. In the first year of his Presidency the medal was not awarded, but in the second year he had the difficult task of delivering an address on the occasion of bestowing the medal to Professor George Darwin for his work on Tides and their influence on the Figures and Motions of the Heavenly Bodies. It is possible that in the preparation of the summary of Sir George Darwin's work, to be found in the *Monthly Notices*, he sought the help of some colleague in the Society, for the subject was rather outside his line of study.

The part that Tennant played in the eclipses of 1868 and 1871

* In this connection it is to be noted that in Kaye and Malleson's *History of the Mutiny* it is recorded that in the early part of 1857 the financial situation at Dehra Dun being somewhat difficult, a scheme for the issue of paper money was adopted on the suggestion of *Captain* (?) Tennant. J. F. Tennant was then Lieutenant.

may be considered in more detail. The first of these eclipses was a notable one in the history of astronomy. There had been no eclipse of importance since that of 1860, when the notion that the prominences are solar was endorsed, and when photography was first employed with any success in eclipse observing. It was Tennant who, in a communication to our Society in March 1867, pointed out that the next step was to decide "whether they are gaseous or composed of solid particles, whether they shine by their own light or by that of the Sun, and even to gather some information as to their constitution," and that the opportunity for doing this would soon present itself. Looking back now from a time when the answers to these questions are commonplaces of astronomy, we may regard the questions themselves as trivial and jejune, but we must remember at this moment that it was Tennant who first asked them. He urged the necessity of observing the eclipse in this sense, and that it was a case in which Government might well help, and this being acceded to, he set a precedent which has since been followed somewhat generously. He, being an Indian official, was naturally entrusted with the organisation, and himself observed the phenomenon from Guntoor. His attempt to photograph the Corona was unsuccessful, which may have been due to haze, but he was able to report a continuous spectrum from the Corona, and one of bright lines from the prominence he examined, whilst the polariscopic observations made by members of his party showed that the Corona is not self-luminous, but shines by reflected light. At the eclipse of 1871 Colonel Tennant was stationed at Dodabetta in the Nilgherry Hills. Trustworthy spectroscopic observations were made and splendid photographs of the Corona, which have now become historic, were taken by Captain Waterhouse and Mr. Hennessey under the superintendence of Colonel Tennant. The conclusion that he arrived at from consideration of his own observations, combined with those of others (*Mon. Not.*, 1872, xxxii. p. 254), is an interesting contribution to the early history of solar physics.

"The following, then, seems to be the constitution of our Sun. There is a nucleus which gives out continuous white light like solid or liquid bodies or even dense gases. Surrounding this is a layer of heavy vapours intensely heated but far less so than the nucleus, and in which, if a state of equilibrium could exist, the heaviest vapours would be lowest. Above this is a layer of glowing hydrogen of very slight density, accompanied by that gas which gives out the line D_3. Still further up, these gases in a cooler state become mixed with what gives out the green line K 1474; and lastly, that alone seems to remain."

Tennant's labours in connection with the observation of the Transit of Venus of 1874 have already been mentioned. It will be remembered that the instruments supplied were to be transferred to some public observatory, and after the operations Colonel Tennant proposed that there should be a solar observatory at Simla, specially for observations with the spectroscope and by photography, and also for the observation of Jupiter's satellites. This proposal was not sanctioned, but it led to the daily photog-

raphy of the Sun by officers of the Indian Survey at Dehra Dun that has gone on for many years past, and has formed, and is forming, such a valuable supplement to the Greenwich series. Tennant was an expert and careful photographer, as was shown by his eclipse results. Perhaps the Greenwich Sun-spot records may also be included in his epitaph.

There are fifty entries to his name in the indexes to the *Monthly Notices*, and he made five contributions to the *Memoirs*. Many of these relate to geodesy, the subject in which he was interested professionally, and some to the eclipses. Besides these there are papers on several other branches. There are some valuable contributions on the optics of reflecting telescopes which were of much help to his friend Dr. Common, and some on other instrumental matters. After his final return to England he appears to have interested himself in cometary orbits, for there are several papers on the subject, but when he had left the Presidential chair he contributed no more, and during the past twenty years has lived in perfect retirement with his daughters at Maida Hill, though he joined the Royal Photographic Society in 1898. As Master of the Mint at Calcutta it is not surprising to find that he felt it his duty to verify the standard weights in his charge, and an account by him of such a verification with the standard weights of England and with the normal standard weight of France will be found at some length in the *Journal of the Asiatic Society of Bengal*, vol. xlix., part ii. 1880. In the previous volume of the same publication there is an account by him of some experiments of coining silver into rupees; and in this connection it may be added that he was a strong supporter of the metric system for general use. He was elected a Fellow of the Royal Society in 1869, but made no contributions to the literature of that body.

He died on 1915 March 6, at the age of 86. His first family consisted of three sons and one daughter, of whom two of the sons now survive. By his second wife, who died in 1878, he had three daughters, all of whom are now living.

A crayon portrait, acquired by his bequest, hangs in our rooms.

He was elected a Fellow of the Society on 1855 June 8.

H. P. H.

Michael Foster Ward, of Ogbourne St. Andrew, Wiltshire, and Bannerdown House, Batheaston, was the eldest son of Mr. Thomas Rawdon Ward, and was born at Round Oak, Englefield Green, Berks, on 1826 March 12. He was educated at Eton College, and subsequently held a commission in the 90th Light Infantry. On leaving the army he entered fully into the duties and life of the parish and county, and at the very commencement of the Volunteer movement he raised the North Wilts Volunteers and commanded them till 1881.

When frequent attacks of sciatica necessitated his going abroad, Colonel Ward first spent some years in Switzerland, and

then went to Partenkirchen, in Bavaria, where he purchased a residence, and built a small English church in his own grounds. He spent every summer and autumn at Partenkirchen, and was there celebrating his diamond wedding when the war broke out, and he became a prisoner of war. On 1914 November 6 he was taken to the local prison, to be transferred to Ruhleben, but as the result of a medical examination he was allowed to remain in his own house and to go about freely within the precincts of the commune. On 1915 May 6 he was permitted to return to England on an exchange of prisoners. After a month in Switzerland, where he went to recuperate after the winter's strain, he safely reached Upton Park, Slough, which had been his winter residence for some years, on June 2. He unexpectedly passed away peacefully, after two days' illness, on 1915 September 13, in his ninetieth year.

Colonel Ward's chief scientific interest was in meteorology. He kept careful records both at home and abroad up to the last. The rain gauge now in general use was the outcome of no less than twenty-one trial gauges with which he had made experiments. He was also genuinely interested in astronomy, and derived much pleasure from his connection with the Society. A paper on the Meteoric display of 1886 November 27 as observed by him at Partenkirchen, Bavaria, was published in the *Monthly Notices*, vol. xlvi. p. 84. Natural history also made a strong appeal to him, and he formed an extensive collection of birds, butterflies, and moths at Bannerdown House.

On 1854 August 17 Colonel Ward married Helen Christina, daughter of Mr. Robert Clark Rattray, of Craighall Rattray, Perthshire; she survives him, together with four daughters and one son, Colonel Thomas Rawdon Ward, late of the West Yorks Regiment. His son being at Partenkirchen on the outbreak of war, was taken prisoner, and is now interned.

He was elected a Fellow of the Society 1863 February 13.

William Willett was the son of the founder of the well-known Chelsea firm of builders, of which he subsequently became the head. He was best known as an energetic advocate of the earlier use of daylight during the spring and summer months. Apparently dismissing as hopeless the possibility of inducing British people to change their habits, he proposed to obtain the desired result by putting all clocks an hour forward on the third Sunday in April of each year, and putting them back again on the third Sunday in September. There was only moderate encouragement from scientific quarters, but the proposal received considerable support from corporations and local councils throughout the country. The "Daylight Saving Bill" was introduced to the House of Commons in the session of 1908 by Mr. R. Pearce, M.P., and after passing its second reading was referred to a Select Committee. Notwithstanding a favourable report, the Bill failed to reach the final stages in the House of

Commons. In the following year the Bill was reintroduced by Mr. Dobson, and on that occasion a Select Committee reported against it.

He died at Chislehurst 1915 May 4, aged 58.

He was elected a Fellow of the Society 1895 May 10.

John Woodrow was born at Kilmarnock on 1858 September 25, and in 1870 removed with his parents to Greenock. Devoting himself to the teaching profession, he was trained in the Free Church College, Glasgow, and in December 1878 started in the Vennel Public School, Greenock. Three years later he was appointed one of the assistant masters in the John Neilson Institution, Paisley, a post which he filled with conspicuous ability and diligence for thirty-four years. Joining in 1884 the Paisley Philosophical Institution and elected in 1885 a member of its Council, he took a lively interest in the Coats Observatory, of which the council of the Philosophical Institution are the legal custodians. He was appointed treasurer in 1896, and on the death of Dr. Henderson in 1904 became convener of the Observatory Committee, rendering unwearied and conscientious service till prostrated by the grave illness which ended fatally on 1915 December 19. He leaves one son and two daughters.

He was elected a Fellow of the Society 1912 April 12.

Dame Margaret Lindsay Huggins, the widow of Sir William Huggins, died on 1915 March 24, in the 67th year of her age, having survived her husband by nearly five years. She was the daughter of John Murray, solicitor, and was born at Dublin in 1848. Her mother died in her early childhood, and Lady Huggins has related how, being left somewhat alone when her father married again, she found a great ally in her grandfather, who loved to walk by starlight, and being a Highlander by birth, knew his stars. He taught her to recognise the constellations, and she pursued her astronomical studies with home-made appliances. Articles that appeared in *Good Words* inspired her to construct a spectroscope, and thus without knowing it she owed her inspiration to her future husband.

On her marriage to Dr. Huggins in 1875 she devoted herself in ardent fashion to assisting him in his work, and took special pride in the part she played in utilising the 18-inch speculum mirror for securing photographs of the ultraviolet region of stellar spectra. In his article in the *Nineteenth Century* in June 1897 Sir William, after speaking of his work in the early eighties, adds, "By this time I had the great happiness of having secured an able and enthusiastic assistant by my marriage in 1875." From that time onwards Lady Huggins was his sole and unwearying assistant, and by her success in photographic manipulations and in visual observations, exhibiting great skill and patience and keenness of sight, she contributed in such large measure to the scientific work that all the later memoirs were issued under the joint names.

She took special part in the investigations of the spectrum of the Orion nebula and the spectra of the planets. Her visual observations of the later spectrum of Nova Aurigæ detected a significant widening of the nebular lines. In the study of the spectrum of the luminosity surrounding radium bromide she was peculiarly interested, and in other investigations in the laboratory she was always ready to take her share in fruitful collaboration. Her name appears as joint author on the title-page of the *Atlas of Representative Stellar Spectra* (1899), which contains, together with some plates reproducing photographs of historical interest and value, the beautiful spectra over a wide range of wave-lengths of many of the brighter stars, both single and double; and she was mainly responsible for the preparation of the photographic enlargements from which the plates were reproduced. She also took her share in the editing of the *Scientific Papers of Sir William Huggins*, which were collected in a single quarto volume in 1909.

She combined skill of hand and eye and artistic judgment and understanding in a remarkable degree. Her friends would receive Christmas greetings from Sir William and herself in the form of a reproduction of some water-colour sketch made in a holiday in the previous year, or in the form of *ex libris* designed by her and sometimes reproduced from wood-blocks cut by her own hand. Many of the treasures with which she and Sir William had embellished their house at Tulse Hill were real discoveries amongst rejected bric-a-brac which her expert knowledge recognised as the handiwork of masters of bygone times. She applied herself in leisure hours to the restoration of these "finds" with a real love and understanding of the handiwork of the original artist. It was difficult to discover where the original work left off and the work of the restorer began. She would humorously declaim against collectors who frequented Christie's, and would maintain that they could never have that keenest pleasure that comes from the power of recognising by real expert knowledge a bit of old and valuable work pushed aside in a heap of rubbish on a dusty shelf.

Those who came to know her in later life could not fail to be impressed by her vivid interest spread over a multitude of varied subjects. Her love and veneration for early art, her knowledge of old literature, her delight in the quaint expressions alike in the art and the words of the ancients, and her application of them to suit the episodes of the life of to-day—the whole bent of her mind seemed to link the medieval past with the present in a way that was full of interest. Her own writings, and even the memoirs and papers describing the scientific work of Sir William Huggins and herself, contained many an archaistic touch. To those who knew her personally it was clear that such allusions, whether in word or illustration, were adopted to some extent with a humorous twinkle, but mainly with a genuine appreciation of quaint appropriateness, and perhaps with an inkling that there might be found stern readers glad enough to be reminded or made aware that old writers like Chaucer and Spenser had cognisance of the existence

of things that are perennial mysteries. Her letters, her very striking letters, were full of the courage that refuses to put up with incomplete expression of thoughts by no means easy to convey, and that will not bow to what is now an almost universally adopted convention of using a letter to convey information without disclosing personality. It has been well said by Miss Cannon, our only Honorary Member, that a letter from Lady Huggins seemed almost like a visit, so vividly did her pen reveal her interesting personality.

She contributed articles to the last edition of the *Encyclopædia Britannica* on the Armillary Sphere and on the Astrolabe. A fuller article on the Astrolabe appeared also in *Astronomy and Astrophysics*, vol. xiii. (1894), illustrated by beautiful photographs and drawings of her own, made from an instrument which had been presented to Sir William and herself. This article is headed "A Summary," but it does not appear to have been published elsewhere in a more extended form.

Her monograph (1892) on *Gio. Paolo Maggini*, based on material collected by William E. Hill and his sons, is an account of the life and work of this Brescian master violin-maker. No one can fail to be struck with the vivid interest she has succeeded in putting into her description of the man and his times. She conjures up a picture of Brescia in the sixteenth century as a background, recalling the many notable contemporaries, and then, with a remarkably penetrating and sympathetic understanding of all the technicalities of his art, she describes the constant efforts of the master to develop the powers of the violin. It is not clear when her interest in the history of the violin began, most probably in 1876. Sir William Huggins, as is well known, was the possessor of a fine violin by Stradivarius, and Lady Huggins accompanied him upon the piano or organ. In 1883 there was published in the *Proceedings of the Royal Society*, vol. xxxv., a paper by Sir William upon the "Function of the Sound-post, and on the Proportional Thickness of the Strings of the Violin." In the *Nineteenth Century* for August 1885 Sir William begins an article on violins by proclaiming his faith in the healing power of music in the following words:—"A fine violin by Stradivari or by Guarnieri is cheap at £500, for it is a thing of beauty and a joy for ever to its possessor, and when it is sold will fetch the price paid for it, together with interest thereon for the time it has been in the owner's hands. No more powerful antidote against the wearing effects of the excessive and anxious activity of our age is to be found than in what may be called the stimulating rest which music affords." Many interesting details about violins are given, and in a footnote he acknowledges as Lady Huggins's the descriptive notes which he introduces in illustration of the distinctions between the English and Italian schools. It is clear that there was as keen collaboration in their study of violins as in their astronomical pursuits.

Lady Huggins interested herself much in educational matters,

and served for some years as one of the managers of a group of Board Schools. She was very keen that boys and girls should be taught the value of the scientific way of regarding things, should relinquish the attitude of indifference to science, and should be made to see how important an element it is in all progress and "how wide is its range from reading the riddle of the stars to settling—what's for dinner?" It is interesting to record her expressed views (1905) on a burning question: "I find that men welcome women scientists provided they have the proper knowledge. It is absurd to suppose that anyone can have useful knowledge of any subject without a great deal of study. When women have really taken the pains thoroughly to fit themselves to assist or to do original work, scientific men are willing to treat them as equals. It is a matter of sufficient knowledge. That there is any wish to throw hindrances in the way of women who wish to pursue science I do not for a moment believe. The lady doctors had a great fight, it is true, but that is old history now, and there were special ancient prejudices involved."

Lady Huggins was elected an honorary member of the Society in May 1903, a distinction and recognition that gave her continued pleasure. In announcing the election at the meeting of the Society, the President spoke as follows:—"For many years the Society has not had any honorary members. In the year 1835 two honorary members were elected, Miss Caroline Herschel and Mrs. Somerville. Miss Caroline Herschel survived until 1848, and Mrs. Somerville till 1872. The only other honorary member the Society has ever had was Miss Sheepshanks, who was elected in 1862 and who died in 1876, since which time we have not been accustomed to see the name of any honorary member on our list of Fellows. This afternoon the Council have elected as honorary members Lady Huggins and Miss Agnes Clerke. It is a pleasure to think that there is a considerable resemblance between the claims of these ladies and those of our original honorary members. Lady Huggins has been associated with the work of her husband as Miss Caroline Herschel was associated with the work of her brother. Sir William Huggins has been accustomed to speak of the work done by the two as their joint work, without any attempt to separate the individual claims, and we naturally accept that testimony to the great efficiency of the work done by Lady Huggins. The work of Miss Agnes Clerke is similar to that of Mrs. Somerville, lying in the domain of scientific writing, and I may say, with reference to her last work, it is not merely an astronomical history, but a work of actual constructive thinking in our science. I am sure that I need say no more to recommend to your good wishes these two ladies." It was an additional pleasure to Lady Huggins that her election was simultaneous with that of Miss Clerke, who was a close friend, much loved and respected by her. On the death of Miss Clerke in January 1907, Lady Huggins wrote an appreciation which was privately circulated. All who were friends of Lady Huggins will recall the warm, thoughtful, and

sympathetic feeling she threw into her friendships in weal and in woe.

A portrait of Lady Huggins in her earlier years hangs in the meeting-room of the Society. Another of later date is given in the beginning of the volume of *Scientific Papers*, but it fails to give an idea of her characteristic vivacity. She was a striking personality, endowed with an unusual combination of keen sensitiveness and a vigorous will. "From first to last I have striven to qualify myself for the post of first assistant to my husband." After his death she devoted herself, in spite of serious illness, to the task of sorting out the records and instruments of value in the observatory, that had been for so many years her happy home at Tulse Hill. Many of these she presented to the (then) astrophysical department of the observatory at Cambridge, to be available for the use of students in connection with the Huggins telescopes which had been presented to the department by the Royal Society in 1908. She was engaged, when her long illness overtook her, in preparing an orderly account of her husband's work, but to her bitter disappointment she was unable to finish it; her strong individuality made her hesitate to share the task with anyone else, and her too early death decides that it can only be completed by other hands. H. F. N.

Carl Theodor Albrecht was born at Dresden on 1843 August 30, and after a general education at the Polytechnic in that city studied astronomy under Professor Carl Bruhns in Leipzig. In the year 1862 General Baeyer initiated the organisation now known as the International Geodetic Association, to combine and co-ordinate the triangulations and other geodetic work, which by that time had been effected by most of the countries of Europe, and in 1866 the Central Bureau of the organisation was created, which then consisted of only two persons besides General Baeyer, but these were shortly joined "by the young astronomer Albrecht, to whom the Association to-day owes so much and such excellent work." The quotation is from a sketch of the history of the Association written by M. Baillaud in 1913.

In 1869 the Prussian Geodetic Institute in Berlin was founded, and the business of the Central Bureau was taken over by the Institute, and thus began a connection which was only ended by Albrecht's death. On a re-arrangement of offices in 1873, General Baeyer entrusted the superintendence of the astronomical work of the Geodetic Institute to Albrecht as Section-Chief, and in 1888 he was named Superintendent of the Department of Astronomical Geodesy.

The work of Albrecht's life has therefore been the carrying out of enterprises undertaken by the Geodetic Institute and by the International Geodetic Association. In his early years the work in hand was the study of the deviations of the plumb line and the curvature of the surface of the earth in different countries, which had indeed been one of the specified objects for which the

International Association was founded; by 1881 the deviations had been determined for a network of 39 points in North Germany, and at 10 of these Albrecht had been an observer. In 1876 Albrecht prepared and published *Formulæ and Tables for the Determination of Geographical Positions*, a fourth edition of which appeared in 1908. He took a large personal share in the observations for the trigonometrical net of North Germany and its connection with other countries. He was one of the observers in the measurement of each of the longitude arcs joining Paris, Warsaw, Bucharest, Pulkovo, Greenwich, and Horta to the North German network, and was one of the first observers, and a skilful one, with the Repsold registering micrometer when it was brought into use about the year 1891. These longitude arcs were measured by means of electro-telegraphy, but the success of wireless communication provided another method, and in 1906 Albrecht planned the work and measured the arc Potsdam–Brocken by wireless telegraphy, which proved a successful experiment. At the XVIIth Conference of the Geodetic Association, held at Hamburg in 1912, he proposed that a new determination of the difference of longitude between Europe and America should be made, in view of the introduction of improved methods. It appears that he contemplated a determination by Hertzian telegraphy, but this being found impracticable, it was arranged to measure the arcs Borkum–Horta (Azores)–New York, by means of the German cable joining those places, and in 1914 the work was begun, Albrecht himself, though nearly 71 years of age, making the observations at Horta. The operations were interrupted by the outbreak of war.

Albrecht's name, however, will be chiefly remembered in connection with the problem of the variation of latitude, with which he was closely associated. The early indications of the movement of the pole of rotation of the earth about its axis of figure, resulting from the work of Küstner, Chandler, and others, induced the Conference of the Association in 1888 to resolve that the subject should be specifically investigated, and that as an experiment, observations for latitude should be made by Talcott's method at certain observatories. The Association, in connection with the U.S. Coast Survey, organised an expedition to Honolulu, where Marcuse of Berlin and Preston of the U.S. Survey observed for a year and a half in co-operation with observers in Germany. The reduction and discussion of the observations were confided to Albrecht, and his report was presented at the XIth Conference of the Association, which was held at Stuttgart in 1895. Largely on the grounds of the report, Professor Foerster, the President of the Conference for that year, drew up a memorandum which led to the inauguration of the international scheme for the determination of the variation of latitude from observations made at specially designed observatories, distributed on the same parallel of latitude round the globe. Four observatories in the northern hemisphere on the parallel of latitude 39° at

first entered into the scheme, and to these two more northern observatories were afterwards added, and later two in the southern hemisphere, but these have now ceased to co-operate.

Work began in 1899 and the discussion of the observations was entrusted to Albrecht. Year by year he has published in the *Astronomische Nachrichten* the results derived from the observations of the previous year for the information of astronomers and those interested, and in 1903 appeared a volume of considerable size, *Resultate des Internationalen Breitendienstes*, Band i., with Albrecht's name as author. Three later volumes of the series have since been published, the last, which bears date 1911, comprising the observations made at the eight stations. To vols. ii., iii., and iv. Professor Wanach's name is added as co-author with Professor Albrecht. All give evidence of skill and care in the preparation, and though subsequent discussion has suggested that alternative methods in some respects might have been preferable, the emergence of an unexpected term (the z term of Kimura), whatever its cause, gives evidence of scientific faithfulness.

From this recital of work done, the tenor of Albrecht's life may be inferred. He was of amiable character, and was active and vigorous, even at the advanced age of 71. In April of last year (1915) he was seized with an internal complaint which led to his death on August 31, the day following his 72nd birthday. He leaves a widow and two sons.

He was elected an Associate of the Society on 1905 June 9.

H. P. H.

Georg Friedrich Julius Arthur Auwers was born at Göttingen 1838 September 12. He was interested in astronomy early in life. When he was still a schoolboy, in 1854, his valuable assistance in observations is referred to by his friend Winnecke; and in July of that year he had the satisfaction of discovering a bright nebula not recorded in Herschel's Catalogue. On entering the University of Göttingen, he took full advantage of the opportunities which the observatory afforded for astronomical research. During his time as student he published many observations, especially micrometric observations of comets and minor planets for position, and determinations of the times of maxima and minima of variable stars. He also computed elements and ephemerides of comets, and indeed ranged over most of the varieties of astronomical work which the rather limited outlook of that time presented.

In 1859 Auwers was appointed Assistant at Königsberg Observatory. He held this post for three years, and then removed to a similar appointment at Gotha. At Königsberg he used the famous heliometer of Bessel, and became one of the small band of observers expert with that form of instrument. Amongst other researches he measured the parallaxes of 61 Cygni, Lalande 21258, ζ Ursæ Majoris, and Procyon, obtaining a general accuracy satisfactory for that period. It was here also that he

discovered a Nova in Scorpius. Specially noteworthy is the investigation that he now began of the irregularities in the motions of Procyon and Sirius, due to their orbital motion round massive companions; for this introduced him to the kind of research in which he made his most valuable contributions to astronomy. The variability of Procyon's motion had been announced by Bessel and partly confirmed by Mädler; but some doubt still existed as to its reality, and no computation of the orbit had yet been made. For this purpose Auwers made an exhaustive discussion of the meridian observations at twenty different observatories from 1750 onwards. He showed that the motion was orbital, confirming Bessel's hypothesis. A period of 39·4 years was deduced and the other elements of the orbit determined. This work formed his dissertation for the degree of doctor in 1862. The similar investigation for Sirius was begun in 1861—the year before the disturbing component was actually seen for the first time by Alvan Clark. There already existed a determination of the orbit by C. A. F. Peters which appears to have been a good approximation. Auwers' investigation, which was not definitively completed for six years, was based on over 7000 meridian observations in right ascension and 4500 in declination. The fact that there were no suitable comparison stars with the low declination of Sirius rendered the discussion of these observations a specially laborious and intricate task. The resulting elements both for Procyon and Sirius have been used in the *Nautical Almanac* and other ephemerides up to the present time.

In tracing the early observations of Sirius and Procyon, Auwers acquired a profound knowledge of the old star catalogues, and learned to understand their defects of systematic error and imperfect reduction, as well as to appreciate the valuable material that could be extracted by suitable methods of refinement and discussion. For Procyon he had had to reduce for himself a series of observations at Greenwich and Palermo. His researches had thus led him to that branch of astronomy which is concerned with fundamental systems of star-places and proper motions, and this now became the main work of his life. The work by which he is best known—his *New Reduction of Bradley's Observations*, 1750–62—occupied him from 1866 to 1876. These observations had been reduced for the first time by Bessel, who published the results in his *Fundamenta Astronomiæ* in 1819; but in the meantime it had become clear that these places of the stars involved large discordances from more modern observations, and the progress of astronomy in the half-century which had elapsed made it possible to apply a much more accurate plan of discussion. The need for extracting the greatest possible value from these famous observations was urgent. Even now, no other early catalogue is available, approaching Bradley in accuracy, until we come to Groombridge in 1810, so that the existence of these records extends the period for determining the motions of the stars by fifty-five years.

Auwers' work was marked by the utmost thoroughness. He

used the original manuscripts of Bradley, and by reducing each observation singly and comparing the results for the same star was able to detect numerous errors. The reduction was strictly *fundamental*; that is to say, it did not in any way depend on star-positions derived and carried back from modern catalogues. By successive steps Auwers established a system of thirty-six clock-stars with right ascensions consistent among themselves, and used these for the reduction of the remaining stars. The equinox was determined from Bradley's observations of the Sun; but owing to the unsatisfactory errors of the quadrant the result has comparatively little weight. Greater difficulty was experienced in the reduction of the zenith distances, which were measured with the quadrant; and it was only after a prolonged discussion, not only of the observations concerned, but also of Bradley's observations with the zenith-sector at Greenwich and at Wanstead and another series by Maskelyne, that sufficient material was obtained for determining the graduation error and nightly zero-point of the instrument. Auwers believed that he had traced the principal errors to the deviation of the limb of the quadrant from the plane, and that this error of figure considerably increased when the quadrant was removed from its northern to southern position; but this conclusion must be considered very doubtful in view of an investigation by Lewis Boss. Writing in 1903, Boss had more ample knowledge of the true positions of the stars in Bradley's time, and he found there was no appreciable difference of the errors in the two positions of the quadrant; on the other hand, the results appeared to be affected by a large flexure of the telescope. This may be admitted without any reflection on Auwers' methods; to allow for a possible change of figure when the instrument was re-erected in a new position was a reasonable precaution, and in making a strictly fundamental reduction for the period about 1755, he was naturally debarred from using any evidence derived from more recent star-positions.

The stars included in the catalogue number 3268. These were re-observed at Greenwich about 1865; and thus were derived the famous Auwers-Bradley proper motions which formed the basis of almost all the pioneer researches on the movements of the stars and their statistical relations. Subsequent workers have applied their own systematic corrections, but, in one form or another, Auwers-Bradley has been the basis on which all stellar investigation rested up to a very recent time. Newcomb's constant of precession, Kobold's researches on the solar apex, Kapteyn's discovery of the two streams, and his determination of the luminosity and density laws in the stellar system—these are but a few of the great advances we owe ultimately to Bradley's magnificent observations, and to the patient industry and resource of Auwers. The catalogue and proper motions were published by the St. Petersburg Academy of Sciences in 1888; the details of the reductions did not appear until 1903.

It was natural that Auwers should apply this work to the

formation of a fundamental system of star-places and proper motions; and he was specially urged to this by the requirements of a project in which he took a deep interest. In 1865 the Astronomische Gesellschaft was founded, Auwers being one of the original members. At its second meeting, in 1867, Argelander brought forward a proposal for the observation of all stars to the ninth magnitude from $-2°$ to $+81°$ Dec. As the observations were to be made differentially, a catalogue of fundamental reference stars was needed, and its formation was undertaken by Auwers. This catalogue contains 539 stars (afterwards extended to 642 by the inclusion of southern zones in the scheme). The observation of these stars was entrusted to Pulkovo Observatory. Various other supplementary observations were used by Auwers in forming the catalogue, but systematic corrections were applied to reduce to Pulkovo as standard. The proper motions of Auwers-Bradley were used, so that the whole system depends systematically on Bradley 1755 and Pulkovo 1865.

This fundamental system of Auwers came into widespread use for the comparison of catalogues and for differential reduction. In comparing it with the rival systems of Newcomb and Boss, it is necessary to bear in mind its original purpose. It was a less ambitious attempt altogether. The Pulkovo observations were made for the particular purpose of the Astronomische Gesellschaft, and no attempt was made to go behind them; proper motions were needed only to carry forward the places for ten years to the mean epoch (as was expected) of the zone observations, and for so limited a time the Auwers-Bradley motions seemed quite adequate. Auwers could scarcely have contemplated that his system would be in use in the *Berliner Jahrbuch* until 1906. About the same time Lewis Boss was working out his fundamental system of declinations. Boss took the bold step of discarding all observations prior to 1820, thus reducing the available interval for proper motions by one-half. The results showed large systematic discordances from Auwers, and there is now no doubt that they were much nearer the truth. In 1903 Auwers published a definitive fundamental catalogue based on a general discussion of the available material, to which Bradley's observations contributed only their legitimate weight, and his system now falls into line with those of Boss and Newcomb. Recent observations appear to show that, so far as right ascensions are concerned, the three systems are all systematically in error by an amount which, though small, exceeds their differences from one another.

The zone of the A.G. Catalogue from $+15°$ to $+20°$ was undertaken by Berlin Observatory. Auwers had been in 1866 elected a member of the Academy of Sciences, and had removed to Berlin. At Professor Foerster's request he undertook the control of this catalogue, although he had no official position in the Observatory. He himself took a large share in the observing. The old meridian circle by Pistor (1829) was allotted to this

work, and in consequence the results do not reach the high accuracy of the later Berlin zones. But the catalogue is a valuable one; and the discussion of the earlier observations, which Auwers contributed, is remarkably thorough.

In later years Auwers continued to devote attention to the refinement and comparison of early observations. He reduced Mayer's observations at Göttingen, 1756–60, and the latest work of his life was the reduction of Bradley's observations of 4219 stars made prior to the erection of Bird's transit instrument and quadrant. In 1897 Ristenpart put forward a proposal to the Berlin Academy of Sciences for the compilation of a "Geschichte des Fixsternhimmels" to contain one general catalogue of all the meridian observations between 1750 and 1900. The scheme secured Auwers' warm support, and by his advice the Academy granted a subsidy for the work. The work has been begun, at first by Ristenpart, Auwers being responsible for the general direction.

From his position as Permanent Secretary and at one time President of the Academy of Sciences, Auwers was concerned in many scientific enterprises besides those that we recognise as belonging to his own particular bent. We can only briefly refer to his share in the organisation of the Transit of Venus expeditions. He himself observed at Luxor in 1874 and at Punta Arenas in 1882. The reports of the German expeditions of 1874 and 1882 were drawn up by him; they occupy six large volumes. The long delay in the appearance of the Bradley reductions was largely attributable to his preoccupation with this work. Of greater interest is his participation in Gill's determination of the solar parallax from the minor planets Victoria, Iris, and Sappho, which led to the value 8″·80 now in universal use. Being unexpectedly left without an assistant experienced in heliometer observing, Gill applied to Auwers, who promised either to come himself or send a trained observer. Ultimately Auwers found it possible to come in person, and he shared with Gill the heliometer observations of Victoria in the summer of 1889. The results amply demonstrated his skill with this difficult instrument. Auwers also undertook the formation of the catalogue of comparison stars from the meridian observations made at a large number of observatories. He showed that, whilst the declinations were in good agreement, the right ascensions showed considerable discrepancies, so that it was necessary to increase their accuracy by an independent process. This led to the decision to make a triangulation of the Victoria comparison stars—a unique feature of the undertaking. Gill speaks in the highest terms of these services, and Auwers' share in this work, in which so many astronomers co-operated, is recognised by the appearance of his name with Elkin's on the title-page. There is a pathos to-day in the words used by Gill: "Such co-operation proves, if proof is necessary, that science knows no nationality, and that the common pursuit of truth for truth's

sake affords 'one touch of nature' which 'makes the whole world kin.'"

In 1912 the fiftieth anniversary of his doctor's degree was celebrated by the institution of the Bradley Medal of the Berlin Academy of Sciences; on this occasion British astronomers presented to him a copy of the portrait of Bradley in the possession of the Royal Society. He was the recipient of many scientific honours. The Royal Astronomical Society awarded him its Gold Medal in 1888, the Royal Society elected him a Foreign Member in 1879, and similar recognition was bestowed by Paris, Petrograd, Vienna, and Washington. In his own country he was Chancellor of the order *pour le Mérite*. In his last years he continued to pursue his astronomical researches with the same laborious industry and perfection of detail that characterised all his work. His death took place on 1915 January 24, the anniversary of the death of his constant friend, Sir David Gill.

He was elected an Associate 1866 May 11. A. S. E.

General Gilbert Defforges served at the front in a very important command for the first five months of the war, but was then threatened with a breakdown in health: he was given a less strenuous command at Orleans, but on March 28 he collapsed during a tour of inspection, and his death followed in a few days. By his own wish he was buried at Roanne (not far from Lyons), where he was born on 1852 March 15: "un enfant de Roanne, dont le père, simple bijoutier, tenait un petit magasin"; and, as added in the funeral discourse of the Mayor, "d'une famille très ancienne et entourée de l'estime de tous." His early education was under the Abbé Tiby at Roanne: he left for the Ecole Polytechnique in Paris, and as a young officer of eighteen went through the campaign of 1870. Once only did the present writer ever hear him refer to that experience. The observatory of the late M. Janssen was the ruined palace at Meudon, wantonly destroyed by the Prussians in 1870: and a visit there was the occasion on which a few sentences lifted for a moment Defforges' cloak of reserve and revealed something of the resentment which the conduct of the war of 1870 had left indelible. At that time the revelation was startling to an Englishman; we can now better understand it, and we can appreciate at something like their full value the words of the Mayor of Roanne in looking forward to the time when he shall be able to return to the tomb of his illustrious fellow-citizen and say:

"Général, ce que vous n'avez pu voir, mais ce à quoi vous avez bien travaillé toute votre vie, ce que vous avez préparé *est accompli*. Notre pays, notre France immortelle que vous avez tant aimée, est à jamais délivrée de la horde barbare qui la souillait. La France, par le sang répandu, par l'héroïsme de tous ses soldats, la France mon Général, *est victorieuse*."

After the terrible experiences of 1870, Defforges rose rapidly in the army. He was captain at twenty-five (in 1877), com-

mandant in 1888. As colonel he was entrusted with a mission to Constantinople 1895–99, ostensibly scientific but really diplomatic, and was so successful that other missions to Rumania and elsewhere were entrusted to him. He returned to France in 1905 as brigadier-general, and was given command of a division at the fortress of Toul in 1910. In 1913 he was quartier-général of the 10th Army Corps at Rennes. In 1911 he visited England on an important military mission; and though his stay was short, he had time to be welcomed by a few of his many friends, and discussed the possibilities of returning to scientific work after his retirement, then in prospect, but never to be realised. A postcard received in January last year reported him still alive and well, "après plus de trente combats," and gave also a good account of his three sons and three sons-in-law, all serving, and five of them at the front. After that the only news received was that of his death.

It may seem strange that a man so conspicuously a soldier at heart should have also risen to scientific eminence; but he began scientific work very early, and showed remarkable aptitude for it. He was attached to the Service Géographique de l'armée, and determined many astronomical longitudes and latitudes in France and Algeria. In 1887 General Perrier wrote to the Astronomer Royal suggesting a re-determination of the Paris–Greenwich longitude, for which there seemed to be two good reasons: first, that previous determinations were in several ways unsatisfactory; and secondly, that the near completion of the geodetic survey of France brought with it the desirability of an accurate link with the English survey. It was arranged that the longitude Paris–Greenwich should be determined in 1888 by a pair of French (Bassot and Defforges) and a pair of English observers (Lewis and Turner); and the longitude Dunkerque-Greenwich in 1889 by one French (Defforges) and one English (Turner) observer. A discrepancy found in 1888 led to a re-determination in 1892, in which again Defforges took part; and in all this work the English observers had ample opportunities for appreciating his skill and scientific acumen.

At the first meeting of the four observers with the Astronomer Royal to discuss plans for the 1888 longitude, the English observers, who were new to longitude work, realised how much there was to learn; and Commandant Defforges' remark, "La longitude, c'est un métier!"—a career in itself, capable of absorbing all a man's best energies—many times recurred to their minds when they encountered this or that strange experience. It was, for instance, something of a shock to Greenwich observers, accustomed to pin their faith to Greenwich clock stars, to learn that for the proposed longitude determination a special list of stars was necessary with places practically determined during previous longitude operations. The French observers had, in fact, gone through experiences rather similar to those which started Lewis Boss on his great work. When Boss as a young man was set to help in

determining the 49th parallel of latitude, he found that the declinations of the standard stars were not good enough, and set himself to improve them, with results now well known: and similarly the French officers of the Service Géographique had found it necessary to discuss and improve the R.A.'s of the stars they used. After the 1888 longitude operations had resulted in a discrepancy between the French and English determinations, Defforges was officially sent to England to help in tracking the source of the discrepancy.

But it was in his own particular work of swinging pendulums that his qualities were most clearly manifested. He devised an extremely accurate method of observation: and he tracked down various minute sources of error of which it will suffice to mention two: firstly, those arising from the imperfection of the knife-edges; and secondly, those arising from the movement of the supporting pier. The knife-edges he found to be a series of facets, so that the pendulum would swing on (say) 5 of these when the arc was large, and 4 or 3 when the arc fell to a smaller value. When the change came from use to disuse of any particular facet, there was a discontinuity in the run of the observations, and by noting these discontinuities (which recurred in different swings, of course) Defforges determined the shape of his knife-edges. The oscillations of the pier he measured and allowed for by an "interference" method of such delicacy that when a crumb of bread was thrown at the pier there was a perceptible movement of the fringes: and if the pier were isolated on a mountain, the approach of a person ascending the mountain could be detected at some distance. With apparatus thus freed so far as possible from systematic errors, he measured the force of gravity at a number of European stations and summarised his results in 1893, pointing out that there was an excess on islands and on coastlines, and a defect in the interior of continents. In 1894 he confirmed and extended these results by observations in the United States from Washington to San Francisco: and the French Academy awarded him the Prix Jérome Ponti in recognition of all this work. In 1895 he further confirmed his conclusions by observations in Russia. Finally, Defforges' masterly discussion of the results obtained led him to suspect another source of error which he believed to be a finite time of transmission of gravity. It was a great sorrow to him to have to leave this work for his diplomatic and military duties: but the call of his country he regarded as paramount. In 1911, in discussing his approaching retirement as above recorded, it was this finite transmission-time of gravity that he mentioned as the problem which he hoped to attack if opportunity should come: and he spoke with confidence of the result. "I am sure," he said, quietly and impressively. He learnt English very rapidly in 1888–1892, and resumed it with great ease in 1911.

When he was twenty-four he married the daughter of the Colonel commanding l'Ecole supérieure de Guerre. Besides his widow he leaves three sons and three married daughters.

It has already been mentioned that all sons and sons-in-law are serving.*

He was elected an Associate of our Society 1898 December 9. In 1889 he was nominated a Correspondant of the Bureau des Longitudes. His papers on the pendulum will be found chiefly in the *Comptes Rendus* from 1888 to 1895: but there is also an important memoir, "Sur l'intensité absolue de la pesanteur," in the *Journal de Physique* and in the *Bulletin de la Société Française de Physique*, 1880.

He was a Grand Officier de la Légion d'Honneur, Officier de l'Instruction Publique, and had received decorations from Russia, Rumania, Italy, Spain, etc., etc. H. H. T.

* The news has since (February 24) been received that his second son Henry was killed on 1915 May 30 in attacking a German trench. He was a Sous-Lieutenant.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir F. W. Dyson, Astronomer Royal.*)

The activities of the Royal Observatory have necessarily been curtailed by the war, especially during the last few months. The attempt has been made to continue observations of which a long series have been made, such as those of the Moon; and observations of parallax and variation of latitude without which previous observations would become valueless. The transit-circle has been kept going at about two-thirds of its former rate; the altazimuth is largely discontinued; the Cookson floating zenith-telescope is being employed nearly at its normal rate; the photoheliograph fully; the astrographic equatorial has been entirely discontinued during the last few months; the 26-inch equatorial is being used for parallax, but hardly at all for photometry, and the 30-inch reflector has not been used; work with the 28-inch equatorial would have been discontinued but for the activity of M. Jonckheere.

Transit-Circle.—6002 observations have been obtained. The Sun has been observed on 129 days and the Moon on 88 days. Reflection observations have been made on 46 nights. The instrument was out of use at the beginning of the year during the mounting of a self-registering transit micrometer brought into use on 1915 March 22. The results are very satisfactory, and, as far as ordinary time observations go, personal equation is negligible. As stated in a paper communicated to the Society in January, reflection observations have been made independently of the direct observations. The method of reduction to the mean of the direct and reflection observations can, if desired, be retained, but it is important to examine more fully this basis of reduction. The stars observed are those of the list prepared by Dr. Backlund and Mr. Hough, whose declinations make them suitable for this latitude.

A catalogue of fundamental stars for the epoch 1910·0 has been prepared from the observations during the years 1906–1915, but its publication has been deferred owing to the exigencies of the war. The catalogue of the stars down to $9^{m}{\cdot}0$ in the Oxford Astrographic Zone (Dec. $+24^{\circ}$ to $+32^{\circ}$) has been completed with

the exception of the proper motions, which are in an advanced stage of computation.

Altazimuth.—1453 meridian transits have been observed. The Moon has been observed 37 times in the meridian and 33 times in other azimuths. The mean error of Delaunay's tables in R.A. is found to be $-0^{s}\cdot21$ from the meridian and $-0^{s}\cdot27$ from the extra-meridian observations. The meridian observations of stars are from the list of "étoiles intermédiaires" between the equator and declination $+24^{\circ}$.

The observations have been materially improved by the substitution of a spider-line for the glass plate on which the R.A. line was engraved, a plate being still retained for the declinations. The reflections from two glass plates made the nadir observations difficult, and there was risk of the plates touching in some places.

Cookson Floating Telescope.—190 plates, each exposed on a group of 4 or 5 Talcott pairs, have been taken, and also 7 plates for the determination of scale. The total number of plates taken to date is 767 (including 30 for scale and other adjustments), of which 37 have been rejected. Measurement is completed as far as the beginning of May 1915. A preliminary discussion of the observations to the end of 1914 was given by Mr. Jones in the *Monthly Notices*, vol. lxxv. p. 542.

Occultations.—18 disappearances and 2 reappearances of stars occulted by the Moon were observed by one or more observers. The reappearance of Lalande 45880 on October 28 after occultation by Jupiter was also observed. The results have been communicated to the Society.

28-inch Refractor.—953 double stars have been measured, including 132 new pairs. They comprise—

224	double stars	with	separation	$<1''$
349	,,	,,	,,	$1''$ to $3''$
289	,,	,,	,,	$3''$ to $5''$
91	,,	,,	,,	$>5''$.

Among the more interesting stars measured are included κ Pegasi, β Delphini, ι Serpentis, ϵ Hydræ, β 612, δ Equulei, and Sirius.

The instrument has been throughout the year at the disposition of M. R. Jonckheere, Director of the Observatory of the University of Lille, who has in part observed the stars of the working catalogue, and has in part continued his discoveries of new double stars and verification of others previously discovered by him. The Catalogue of double stars to be published in the *Memoirs* of the Society, which he is preparing, is now in the hands of the printers.

Astrographic Equatorial.—91 satisfactory chart plates of the zone Dec. 25° to 31° were obtained during the year, making the total of good plates 206 to date. The instrument has been out of use since the beginning of November. The determination

of the proper motions of the stars in vol. iii. of the Astrographic Catalogue by comparison with Lalande, Argelander, and the catalogues of the Astronomische Gesellschaft has made some progress. Zones 70° to 74° have been completed during the year, zones 65° to 69° carried as far as R.A. $9^h\ 40^m$, and zone 64° is about half finished. With the duplex micrometer, plates at an interval of about twenty years have been compared for the detection of any large proper motions that there may be in the stars of the *Bonn Durchmusterung*. 125 fields out of 152 possible ones between the limits 65° to 69° of declination have been examined.

Thompson Equatorial.—206 plates have been exposed for parallax determinations and put away without being developed to await a second exposure; 248 plates have been re-exposed at the end of the half cycle. A total of 313 plates has been measured by two measurers, of which number 86 are duplicates of previous measures. The parallaxes of 40 stars were published in the *Monthly Notices* for June 1915. During the year 53 good photometry plates of Kapteyn areas have been obtained. These are mainly fields in zone +15° declination. The photography of this zone is completed, and the measurement fairly advanced, but at present is at a standstill.

6-inch Astrographic Triplet.—The photographic magnitudes of 5500 stars between the limits of declination 65° 0′ and 75° 0′ were published at the beginning of the year.

Franklin-Adams Charts.—These were examined by Mr. Melotte for star clusters, and the catalogue formed was published in the *Memoirs* of the Society.

Photoheliograph.—With this instrument photographs were obtained during the year 1915 on 235 days, of which, however, 18 were days of poor definition. In the year ending 1915 October 31, photographs have been obtained on 314 days at the Cape Observatory; and 8 photographs have been received from Kodaikánal, and 11 from Dehra Dûn, making the daily record complete from 1914 January 1 up to 1915 May 31. In the seven months ending 1915 October 31, there are still 6 days unrepresented, but photographs will probably be forthcoming for these from one or other of the Indian observatories.

The solar activity has increased rapidly during 1915, and a well-marked secondary maximum was in evidence at the end of July and beginning of August, the mean daily spotted area for these two months being about 1100 millionths of the Sun's visible hemisphere, as compared with 7 for 1913 and 152 for 1914.

This striking increase has necessarily made the work of measurement very heavy, but by the end of the year the measurement of the Greenwich photographs had been effected as far as 1915 September 15, and of those taken at the Cape as far as 1915 July 8; and the entry and reduction of these measures was well forward. The copy for press of the Photoheliographic Results for 1914 is completely ready for the printer.

Personal.—At the present time Mr. Burkett, Junior Assistant,

and eighteen computers are absent on military service. Mr. Witchell and Mr. Edney are lent to the Hydrographic Office of the Admiralty, and Mr. Jones to the Inspectional Department of the Woolwich Arsenal.

The work of the observatory is kept up by the additional exertions of the staff. Mr. and Mrs. Maunder have very kindly returned to the observatory as voluntary workers, and are engaged in the solar department.

Royal Observatory, Cape of Good Hope.
(Director, Mr. S. S. Hough, H.M. Astronomer.)

Transit-Circles. — The programme of observations of the Backlund-Hough stars, together with a selection of stars from Boss's fundamental catalogue, has been continued throughout the year with the new transit-circle. The following observations have been obtained:—

Observations of Right Ascension:—

Number of meridian transits . . .	8124
Determination of collimation by collimators	109
,, ,, ,, by reflexion and reversal	33
,, ,, level	799
,, ,, azimuth	149
Observations of Meridian Marks	1451

Observations of Zenith Distances:—

Determinations of Z.D.	8083
,, ,, runs	401
,, ,, nadir	789
,, ,, flexure	81

Included in the number of observations are:—

Observations of the Sun on	156 days
,, ,, Mercury ,,	47 ,,
,, ,, Venus ,,	59 ,,

The non-reversible transit-circle has been used by Mr. J. Voûte, of Leyden, in continuation of his programme for the determination of stellar parallaxes.

Evening observations were resumed in May, and morning observations in August. The working list comprises 115 parallax stars with an average of 5 comparison stars to each. During the year the following observations have been secured:—

Evening observations . .	3191 transits
Morning ,, . .	1987 ,,
Azimuth stars	9

Heliometer.—The observations of the major planets at the time of opposition have been continued, and the following observations obtained:—

Opposition of Neptune .	56 obs. in distance on 7 nights.	
,, ,, Uranus .	48 ,, ,, ,, 6 ,,	
,, ,, Jupiter .	24 ,, ,, ,,	on 5 nights.
	24 ,, ,, position-angle	
,, ,, Saturn* .	32 ,, ,, distance on 4 nights.	

Victoria Telescope and Astrophysical Laboratory.—The telescope was used on 141 nights during the year. During July and August and again during November the spectrograph was dismounted for the purpose of obtaining direct photographs of Jupiter's Galilean satellites near the epochs where the planet is stationary. Thirty-seven photographs were obtained, each with 6 images of Jupiter and its moons and 2 exposures on a selected star region.

During the remainder of the year the instrument was devoted to the photographing of stellar spectra for the determination of radial velocities, and 134 long-exposure star plates were secured in addition to 29 daylight plates and 13 focus plates for instrumental control.

The 18-inch visual telescope was used for measures of Taylor's comet on one night.

In the laboratory 135 plates of star spectra have been measured. The new four-prism laboratory spectroscope has been tested, and found to give excellent definition of spectra from the extreme red to the limit of transparency of glass in the ultra violet. The "lead pencil" comparison spectrum has been photographed and measured from λ3593 to λ6720, except in the region previously published, and a number of metallic and other spectra have been photographed.

The Astrographic Telescope.—The following photographs have been secured with this instrument:—

	No. of Plates.
Magnitude plates	49 (98 exposures)
,, ,, (with screen attachment) . .	8 (160 ,,)
Jupiter VIII. region	6
Variable star regions	12
Comet 1915 *e* (Taylor)	7
,, 1913 *f* (Delavan)	5
,, 1915 *d* (Mellish), for position . . .	20
,, ,, ,, for form of nucleus . .	12
Parallax plates	14 (of which 7 have been re-exposed at a second epoch)
Repetition chart-plates for proper motion . .	6
Double-star plates	57
Miscellaneous plates	9

* Still under observation 1916 Jan. 1.

The plates of the J VIII. region were taken at the request of Mr. Knox Shaw to facilitate the reduction of observations of the satellite made at Helwân, those of the variable star regions at the request of Dr. A. W. Roberts to furnish data for the magnitudes of his comparison stars.

Photoheliograph.—Daily photographs of the Sun to supplement the Greenwich series have been taken on 315 days. In all 654 photographs were taken, of which two have been rejected and the remainder forwarded to Greenwich.

Occultations.—Thirty-eight separate phenomena of occultations of stars have been observed during the year, viz.:—

Disappearance at dark limb . .	20
Reappearance „ „ „ . .	18

The observations of occultations during the years 1907–14 have been reduced and prepared for press.

Reductions of Meridian Observations.—The reductions of meridian observations to apparent place have been completed to 1915 October 27 in Right Ascension, and to 1915 December 7 in Declination. The reductions to mean place have been computed for all observations to 1915 July 2, and the mean places formed for all observations to the end of 1913.

A volume containing details of the meridian observations during the years 1905–8 has been issued during the year, while a further volume containing similar details of observations in the interval 1909–11 has been passed through the press. A catalogue based on the combination of the series of observations 1905–11 and reduced to the equinox 1900 has been passed through the press and issued.

The results, together with a discussion, of the meridian observations of the Sun, Mercury, and Venus for the years 1907–11, have been printed as vol. viii., part iv., of the *Cape Annals.*

"Carte du Ciel" Reductions.—Revision work consisting of comparisons with the C.P.D. and comparisons of overlapping areas has been continued throughout the year. 670 pairs of overlapping quadrants have been compared during the year and the discordances have been completely examined and revised for 372 plates and in part for 320 additional plates. The final copy for press has been completed for 359 plates, and proof-sheets have been passed for 172 plates.

Vols. ii. and iii. of the *Cape Astrographic Zones*, containing the rectangular co-ordinates and measures of diameters of stars contained on the astrographic plates in zones $-42°$ and $-43°$, have been issued, while the manuscript for vol. iv. and part of vol. v. has been sent to the printers. Proof-sheets of the former of these volumes have been passed for the first seventeen hours of R.A.

A readjustment of the plate-constants of zones $-41°$ to $-48°$, based on the reconciliation of the residual systematic discordances between overlapping quadrants, has been effected in the course of the year.

The work in connection with the conversion of the diameters of the astrographic zones into photographic magnitudes was brought to a conclusion as far as the standardisation of 24 selected areas in 45° southern declination. The comparison of these areas with the South Pole comprises individual observations of 999 selected stars brighter than the 12th magnitude, the final results depending on the mean of six diameters for every star.

The resulting magnitudes are based on the standard magnitudes of 33 polar stars which were previously determined by a fundamental method described in *Monthly Notices*, vol. lxxv. p. 150.

The material available through the standardisation of the selected areas appeared to be sufficiently accurate and extensive for a general standardisation of the magnitudes of the C.P.D. to be undertaken. In order to test the reliability of the results by a comparison with the photographic magnitudes of stars in the northern hemisphere, the relation between the magnitudes and numbers of stars contained in the C.P.D. was established with the aid of Stratonoff's star counts. A comparison with Chapman and Melotte's results showed a most satisfactory agreement in zero point and scale between the Cape magnitudes and those of the Harvard North Polar Sequence, provided that the latter are reduced to the Mount Wilson system in accordance with Professor Seares' observations. It also appears from a detailed comparison between photographic and visual magnitudes that the stars in the Galaxy are distinctly bluer than those near the galactic pole, but that the degree of blueness, *i.e.* the colour correction, does not depend on the apparent magnitude.

A full account of the investigation is now prepared for publication in the *Annals*, and a paper discussing some results of general cosmical significance, particularly with regard to the question of the absorption of light in space, will shortly be presented to the R.A.S.

Time-Signal Service.—The wireless time-signal which has been in operation from 1914 September 1 has been continued throughout the year. The signal from a clock in the Observatory automatically operates a key in the wireless station at Slangkop by means of currents transmitted over land lines. In other respects the usual time-signal service has been continued.

Miscellaneous.—The meteorological observations and seismograph records have been maintained as in previous years.

Royal Observatory, Edinburgh.
(*Director, Professor R. A. Sampson, Astronomer Royal for Scotland.*)

General—Early in the summer the whole staff volunteered their services for war work, through the Secretary for Scotland. In consequence, in the month of June Mr. Wrigley was withdrawn and attached to Admiralty work at Deptford, and in August Mr.

Storey was withdrawn also and has since been engaged in London upon some confidential calculations. Professor Sampson and other members of the staff were employed at the Observatory upon the construction of an experimental instrument. Under these circumstances, during the latter half of the year fresh astronomical work has been unavoidably cut down to a minimum.

Transit-Circle and Clocks.—Consistently with the programme of last year, close observation has been kept upon the instrumental constants of the Transit-Circle with regard to their fluctuations, and upon the going of the clocks. Some work was given to the construction of an experimental clock, but this is interrupted for the time being. Preparations have been made for setting up and thoroughly testing under constant temperature in the clock-cellar certain standard clocks of which the loan has been promised.

Arrangements are in progress for extending to H.M. Dockyard, Rosyth, the system of time-signals sent out by the Observatory.

The temperature control of the clock chamber has in general worked well. It is necessary from time to time to reject a small quantity of mercury from the columns of the controlling thermometer, as, sooner or later, the upper surface gets into an adhesive state.

Wireless Time-Signals.—The wireless receiving apparatus was restored to the Observatory by the beginning of the year, and after some delays, due in part to prohibition of sale of ordinary pieces of apparatus, observations of the Paris 11.30 P.M. rhythmic signals were resumed nightly on March 11. At the end of May permission was obtained to send again by telegram to Paris Observatory the daily result of the comparison, and on June 3 the daily telegrams which had been interrupted at the beginning of the war were resumed and have been continued regularly since.

The mean of 221 comparisons gives the difference *Paris–Edinburgh* $= +0^{s}\cdot05$. In the previous year the value obtained was $+0^{s}\cdot11$.

Solar Spectroscope.—The observations have been made with the 21-foot Rowland concave grating, the property of the University, and lent by Professor Barkla. They have been directed specially to determining the origin and character of the systematic differences in the Sun's equatorial velocity found at different observatories. Seventeen plates of very good quality were obtained, each containing five pairs of exposures upon opposite extremities of the solar diameter, employing the region about λ6300 in the 3rd order. All these have now been nearly completely measured in two positions by each of three observers.

15-*inch Equatorial.*—The programme of double-star observations was continued until interrupted by Mr. Storey's withdrawal.

24-*inch Reflector.*—In view of the improbability of obtaining means for replacing this instrument in the near future, consideration has been given to finding a problem to which the telescope can be applied without spending a large amount of money upon it, and to which its inferior figure will not be seriously prejudicial.

Stellar magnitude by means of the photo-electric cell seemed to offer the desired field, and studies are in progress accordingly. A Laby string electrometer has been acquired from the Cambridge Scientific Instrument Company, and experimental cells coated with sodium are being constructed in the Observatory.

Astrographic Chart.—The whole of the plates taken at Perth, Western Australia, for zones $-38°$, $-39°$, $-40°$ are now measured and copy made for press. Standard co-ordinates have been computed completely for zones $-39°$, $-40°$, and up to 7^h for zone $-38°$. Plate constants have been computed for zone $-40°$ completely, and up to 21^h for zone $-39°$. Counts are in progress to determine the number of images of each photographic diameter recorded in the middle area and margin of each plate.

Seismograph.—Observations have been continued regularly, the records read, and results communicated to Shide.

Electrograph.—Observations were continued till June, after which date they were stopped for the time being.

Meteorological Observations were made regularly. The Dines pressure-tube anemometer with Munro-Rooker direction recorder continues to give very satisfactory results. It has now been fitted with a pressure-gauge to check the absolute value of its indications.

Armagh Observatory.
(*Director, Dr. J. L. E. Dreyer.*)

Vol. ii. of Tycho Brahe's Works was published in the summer, and vol. iii. is in the press. The printing of the first volume of the Observations (vol. x.) is progressing slowly and has nearly reached the end of the year 1583. But it will soon have to be stopped, as it is impossible to obtain access to some of the manuscripts wanted, on account of the war.

An examination of Tycho's Star Catalogue is in progress. More than 10 per cent. of the positions are very erroneous, in most cases owing to errors of reduction.

Cambridge Observatory. (*Director, Professor A. S. Eddington.*)

After a few months' progress under normal conditions, work at the Observatory has again been handicapped by an unavoidable reduction in the staff. Mr. Entwistle, second assistant, was occupied with military training from the middle of April, and he took a commission on June 26. The boy-attendant left on October 30 to enter optical instrument works. At the end of the year Mr. Hartley, first assistant, accepted a post as naval instructor for the duration of the war. Thus the new year opens with no regular staff at the Observatory except the Director.

During the year the chief attention has been given to the Sheepshanks Equatorial. The trouble with the driving-clock, referred to in the last report, was soon overcome, and observations for stellar parallax were begun in March. Excluding plates for adjustment, 49 photographs have been taken during the year. Of these 25 were for stellar parallax; but some of the earlier plates do not attain a sufficiently high standard to be used. Parallax observations were suspended in September (except for plates needed to correspond with those already taken), because, in view of the uncertain outlook, it was impossible to count on obtaining the necessary complementary plates. Since then photographs for determining the light curves of variable stars have been taken; this work was unfortunately very much interrupted by bad weather. The longest series is a set of ten plates containing altogether 98 exposures of 10^m on SU Aurigæ. Another series, taken by Mr. H. Glauert, Isaac Newton Student, consists of 48 exposures on V Arietis.

For this photometric work a new micrometer has been obtained. It was purchased by, and is the property of, the Trustees of the Isaac Newton Studentship Fund. It is provided with movable wires for measuring the diameters of star-images; and the optical arrangements are such that the corresponding images on two plates can be seen simultaneously, thus facilitating an accurate comparison.

The use of wireless apparatus for the receipt of Paris time-signals was restored to the Observatory in June, in consequence of an application made to the authorities through the President of the Royal Astronomical Society. The signals have been received regularly since then.

The printing of the ledgers of the Cambridge Astronomische Gesellschaft Catalogue has now been completed so far as the main catalogue is concerned. About three-quarters of the appendix, consisting of revision observations, has also been printed.

In referring to the theoretical researches which have been carried out, it is difficult to draw a line between those directly connected with the Observatory and those forming part of the general astronomical activity of the University; but the following seem naturally to find a place in this report. An investigation by the Director and Mr. Hartley of the radial velocities of stars according to the ellipsoidal hypothesis has been published in the *Monthly Notices*. Two papers by Mr. Glauert on the apparent changes in the rate of the Earth's rotation, deduced from observations of the Sun, Mercury, and Venus, have also been published by the Society. Mr. H. W. Unthank, Isaac Newton Student, has been making a determination of the mean parallaxes of stars of different magnitudes, and his investigation is now completed.

The usual demonstrations in practical astronomy by the first assistant were suspended in the Michaelmas term, there being no students. As usual a large number of members of the University and their friends have attended the Saturday evening exhibitions of celestial objects with the Northumberland telescope.

Solar Physics Observatory, Cambridge University.
(*Director, Professor H. F. Newall.*)

Spectroheliograph.—Photographs of the Sun's disc in K_{2-3} light have been obtained on 112 days, and photographs of the prominences at the limb on 95 days.

During the early part of the year there was a marked development of solar activity, extending over several weeks; apart from this the gradual increase of activity appears to be sustained.

The photograph of the limb taken on 1915 April 19 recorded an unusually fine arched prominence on the south-east limb. A paper by Mr. C. P. Butler relating to it was communicated to the Society in May (*M.N.*, lxxv. 553).

War conditions have made it impossible to get the designs for the new spectroheliographs carried out; and accordingly several small alterations have been made in the old instrument, which was transferred from South Kensington. In May an iron framework was substituted for the wooden base plate of the spectrograph section of the instrument. The change has made a marked improvement in the stability of the instrument. In June the jaws of the primary slit were reworked, and the mechanism for widening the slit was repaired. The plate-holders were adapted to hold 5×4 inch plates, and this size of plate has been used since May 19.

For the period 1914 October 1–1915 June 30, the Director of the Kodaikánal Observatory has sent 246 spectroheliograms showing the solar disc in K_{2-3} light. Of the 27 days missed in the Kodaikánal records during this period the Cambridge record has photographs for 8 days.

Photoheliograms.—Daily photographs of the Sun taken with the Dallmeyer photoheliograph at Dehra Dûn have been received, and the negatives are stored at the Science Museum, South Kensington. Positive prints have also been received from Dehra Dûn. Spectroheliograms have been enlarged to the same scale for comparison.

Study of Sun-spot Records.—Considerable progress has been made in the study of the areas and life-history of Sun-spot groups and in the study of recurrent groups, and a comparison of the life-histories of single spots and of spot groups is in progress.

McClean Solar Instruments.—Successful photographs of Sun-spot spectra in the region between $\lambda 5300$ and $\lambda 5500$ have been obtained.

The chemical origins of the lines in this region have been revised by Mr. Baxandall, and probable origins have been found for about 150 lines for which Rowland gave no identification. This work is part of a much more extensive revision of the origins assigned in Rowland's tables of solar wave-lengths.

A memoir by Mr. J. B. Hubrecht on the Solar Rotation in June 1911, from spectrographic observations made with the McClean solar instruments, has been published as volume iii.

part i. of the *Annals of the Solar Physics Observatory*. This is the only part of the *Annals* yet issued.

Investigations of Stellar Spectra.—Considerable study has been devoted to the behaviour of the many forms of spectra of carbon and compounds of carbon in available types of celestial spectra.

Spectra have been specially studied with the object of elucidating the origin of conspicuous bright lines, which appear in Moore and Sanford's published photographs of η Carinæ and in Stebbins's photograph of o Ceti. No satisfactory evidence has been found for the appearance of the lines in any available records either of published wave-lengths or of laboratory photographs.

Work in the Laboratory.—The continued detention at Odessa of the instruments taken to the Crimea for eclipse observations in 1914 has impeded progress. The temporary spectrograph in Littrow form constructed with the 6-inch Anderson grating and the 6-inch photovisual lens of focal length 20 feet, was found not to give sufficient light for the work to be accomplished. Accordingly the grating was replaced by two glass prisms of aperture 6 inches and angle 45°, the light being returned through the prisms by reflection from the silvered surface of a third prism. With this instrument, photographs of the hydrocarbon spectrum on a large scale of dispersion are being successfully obtained.

Investigations in Atmospheric Electricity.—Investigations have been continued by Mr. C. T. R. Wilson on methods and apparatus for studying quantitatively the principal phenomena of atmospheric electricity. The chief results of interest obtained by the application of these methods have been in connection with the rapid changes of the electrical field in thunderstorms, especially the instantaneous changes accompanying lightning flashes.

Lectures.—Mr. G. W. Walker, F.R.S., who was appointed Deputy, as University Lecturer in Astrophysics, for Mr. Stratton during the May term, gave a course of lectures on Terrestrial Magnetism. Lectures were given in the October term by Professor Newall on the Structure of the Sun and Thermodynamics.

Personal.—Owing to the war the staff has been depleted. The Assistant Director, Mr. Stratton, has been absent the whole year, and as Captain in the Engineers (26th Signal Company) has been with the British Expeditionary Force in France since July, and was mentioned in Sir John French's despatches. Mr. W. E. Rolston received his commission and left the Observatory in June to join 2/5 Weald of Kent Battalion, The Buffs. Mr. Manning has been employed at munitions since May.

Dunsink Observatory.

(*Director, Professor H. C. Plummer, Royal Astronomer of Ireland.*)

The weather during the past year seems to have been more unfavourable for observations than usual, though earlier records are not available for comparison. There were 80 really fine nights,

but on 34 of these bright moonlight or other causes prevented photographic observations. By using partially fine nights 207 plates were taken with the reflector for the study of variable stars, and 18 miscellaneous plates, on 72 nights. The number of plates measured was 170. Even in fine weather the condensation of moisture is a great hindrance to the work.

A discussion of the cluster variable RR Lyræ has been published during the year, and a series of plates for the study of V and X Lacertæ has been completed. Other stars continue on the programme.

Determinations of time with the Pistor and Martins meridian circle were made on 79 nights. The time-ball in Dublin is being transferred from its present position to one where it will be of greater service to the shipping in the port.

Among other investigations may be mentioned a study of the distribution of stars in globular clusters, based on the counts recently published by Professor S. I. Bailey, and a discussion of the motions and distances of the brighter F type stars, founded on what may be called the galactic hypothesis. In the latter volunteer help was received from Mr. O. R. Walkey, which deserves grateful acknowledgment.

The staff, consisting of the Director and Mr. Martin as assistant, remains unchanged.

Durham University Observatory.
(*Director, Col. E. H. Hills, C.M.G.*
Observer, F. C. H. Carpenter, B.Sc.)

During the absence of the observer on military service meteorological observations only are being carried on.

Glasgow Observatory.
(*Director, Professor L. Becker.*)

The reductions and discussion of the observations of stars in the vicinity of the pole have made good progress and will shortly be finished. The time-service and meteorological observations have been carried on as in former years.

Liverpool Observatory, Bidston.
(*Director, Mr. W. E. Plummer.*)

The Observatory having an extensive sea horizon has found its activities much hampered by the police regulations requiring that no light shall be shown seawards. The effect of the enforcement of the regulations has been to reduce the number of observations to a minimum, and to confine these to the maintenance of the routine work, sufficiently described in earlier reports.

The number of chronometers deposited, as well as all technical apparatus submitted to test, has been diminished and the usefulness of the Observatory temporarily reduced.

The meteorological section of the Observatory has preserved the usual activity, and there has been no breach in the continuity of this class of observations.

Seismological records have been continued without interruption throughout the year. The Milne-Shaw form of instrument, with effective damping, was brought into permanent employment on 1915 January 1, and has performed with great satisfaction from that date.

The removal of the radio-telegraphic apparatus and the difficulty of obtaining weather observations from neighbouring stations have interfered with the scheme, mentioned in earlier reports, by which it was proposed to incorporate the effect of meteorological elements in tidal predictions. The general effect of the inquiry has been to show that the error of the harmonic constants of the tides of the port is greater than was supposed, and that the effect of the diurnal inequality is imperfectly known.

The diminished activity of the Observatory is entirely attributable to war conditions.

Radcliffe Observatory, Oxford.
(*Director, Dr. Rambaut, Radcliffe Observer.*)

The work of this observatory during the past year has been hampered in more ways than one through the effects of the war. At the very beginning of the year the observatory was deprived of the services of Mr. J. G. Balk, who had become a very useful member of the staff. On January 1 he left to join the army. This, of course, necessitated a redistribution of the astronomical and meteorological duties amongst the remaining members. Later in the year Mr. H. G. Barrett volunteered for service under Lord Derby's recruiting scheme.

During the year 1915 the programme of work with the 24-inch photographic refractor, which consists in photographing Professor Kapteyn's "selected areas" for the purpose of determining the proper motions of stars down to the 14th magnitude, has been carried on as in recent years, so far as the reduction in our numbers and unfavourable weather would permit. In connection with this scheme only 38 photographs were secured, each requiring two exposures of 30 minutes each—very little more than half the number (72) which was obtained in the previous year. Two of these are more or less incomplete, leaving 36 plates which are considered satisfactory for the purpose in hand. During the year 24 plates, exposed but not developed, have been packed in air-tight boxes, to be exposed again to the same region of the sky when ten years have elapsed. Eleven dozen plates have now been stored in this way.

At the end of last year, out of the 136 "selected areas" of Professor Kapteyn's plan, which have been undertaken for proper motion by the Radcliffe Observatory, the working list contained 33 which had still to be observed. Of these 31 lay between $1^h\ 50^m$ and $11^h\ 59^m$ in R.A., and 8 of them in the fourth hour of R.A. In order to overtake these arrears early-morning watches were again arranged during the later months of the year (September to December), but owing to the very unfavourable weather during most of that period, or to the proximity of the Moon, only 9 plates could be secured. Although every effort was made to wipe these off, at the end of 1915 the working list still contained 30 areas not yet satisfactorily photographed. They are distributed in the first fourteen hours of R.A. as follows:—0, 1, 1, 3, 2, 6, 2, 1, 5, 2, 2, 3, 1, 1 respectively.

In last year's report it was stated that it would probably be advisable to take some of the proper-motion fields again with plates which come up to the normal standard of excellence. Thirteen such fields were added to the working list, and 5 of them have been successfully re-photographed during the year.

In order to test the stability of the mounting of the photo-refractor, observations of the errors in altitude and azimuth of the polar axis were made on February 24. These observations showed a change of only $6''{\cdot}8$ and $1''{\cdot}4$ respectively from February 5 of the previous year. On March 17 the axis was readjusted, after which the errors were found to be $+2''{\cdot}1$ in altitude and $+1''{\cdot}0$ in azimuth, which were considered to be satisfactory.

The 10-inch Barclay equatorial has been used for miscellaneous observations, including the occultation of the star Lal. 45880 by Jupiter on October 28. It has also been employed as in recent years by Mr. Barrett for observations of a selected list of variable stars. This list includes ST Draconis; VV Aurigæ; 4, 1913 Tauri; and 5, 1913 Arietis. Of these stars 46 observations (146 separate comparisons) on 12 nights have been secured.

The measurement of the stellar parallax plates, taken in recent years with the 24-inch refractor, and the reduction of the measures have now been completed. Four Kapteyn plates have been measured in the course of the year and 14,684 micrometer measures have been effected for parallax. Adding 2480 measures, which have been made for the purpose of examining the errors of the micrometer screw, we have a total of 17,164 micrometer measures of photographs made with the measuring machine during the year.

At the end of 1914 the card catalogue contained 5321 separate determinations of the parallaxes of 2350 stars (*not* 2462 as given by mistake in last year's report). During the past year 65 separate values were deduced for stars in the region of B.D. $+44^\circ$ 1408 and 264 separate values for stars in the region of B.D. $+25^\circ$ 495, by which 40 stars were added to the catalogue. The total number of stars for which parallaxes have been deduced in the course of this investigation is thus 2390, and the number of separate determinations 5650. The questions of deducing the mean value of the

parallax for each star, of the probable error attaching to it, the general discussion of the results, and the determination of the photographic magnitudes of all the stars, are now engaging attention.

Volume li., part iv., of the *Radcliffe Observations*, containing the results of meteorological observations during the year 1914, was printed early in the year and a limited number of copies distributed. Part v. is now in the printers' hands. This part, which completes the volume, in addition to the usual results for 1915, contains the observations of underground temperature at Oxford made daily by means of platinum-resistance thermometers during the twelve years 1898 to 1910, with a discussion of the principal results to be deduced from them.

University Observatory, Oxford.
(Director, Professor H. H. Turner.)

The reductions for the Vatican plates of the Astrographic Catalogue have gone on steadily: zones $+60°$ and $+59°$ (to end of 18^h) have during the past year been added to the list of those fully reduced, making nearly 6 zones completed out of the 10 to be done; zone $+64°$ was printed and distributed as volume i. early in the year, and zone $+63°$ is all in type except the Introduction.

For clearness it may be repeated that these plates are taken and measured in Rome; but as there was some difficulty about the computations, these are being undertaken at Oxford, with funds supplied from the Vatican (after the work had been started by the spontaneous generosity of Mr. A. F. Lindemann, F.R.A.S.) Some of the proof-reading is also done at Oxford. The collaboration has worked very smoothly. It is a pleasure to record that when there was some momentary anxiety about the transmission of funds from Rome, a safeguard was supplied from the "Elizabeth Thompson Fund" in the United States through the instrumentality of Professor E. C. Pickering; and, further, that the ingenuity of Father Hagen very promptly and independently devised means of meeting the difficulty for two years ahead; so that the Elizabeth Thompson benefaction remains at present untouched, as a reserve, and a symbol of international courtesy at a critical time.

The harmonic analysis investigations of rainfall and temperature, mentioned in the last report, led to some interesting developments tending to confirm the existence of definite "chapters" of meteorological history, with discontinuities between consecutive chapters. A new line of evidence presented itself in sensible differences between the "even" and "odd" chapters (numbering them in sequence). The evidence obtained to date was collected and arranged in a paper to the Royal Meteorological Society (*Quarterly Journal*, 1915 October).

The Director has continued his superintendence of the seismological work at Shide. The experiments for improving the Milne pendulum, made by Mr. J. J. Shaw and Mr. J. H. Burgess, have met with gratifying success; and the time is now ripe for replacing the early Milne pendulums by the modern (more sensitive and damped) pattern. The Shide bulletins have been further modified so as to give material directly available for the improvement of the tables. Attention has been called to the possibility of a new form of transmitted wave. Using the names "pulse" and "shake" for the waves denoted by the letters P (longitudinal) and S (transverse), then "pulses" reflected once (PR_1) or twice (PR_2) and "shakes" similarly reflected once or twice (SR_1 or SR_2) have been recognised; but after a few reflections no more are to be observed. The suggested new phenomenon is a "pulse" reflected an indefinite number of times—indefinite because (as suggested) pulses reflected 100 or 1000 or any intermediate number of times may all arrive simultaneously and reinforce one another so as again to be noticeable, and the combined result may arrive so near the "shake" as to be mistaken for it. The recognition of the phenomenon removes the confusion; but it is not yet certain that the proper explanation has been given.

With the able assistance of Miss M. A. Blagg, six more of Baxendell's Variables have been fully reduced and printed (*M.N.*, lxxv. p. 398, and lxxvi. p. 158). The prolonged study of two of these stars, S Herculis and R Leonis, in which a paper by the Rev. T. E. R. Phillips on S Herculis played an important part, has led to the suspicion that the adopted type of formula, *e.g.*

$$2362902 + 312{\cdot}9\,\mathrm{E} + 25\sin(2^{\circ}{\cdot}75\,\mathrm{E} + 318^{\circ}),$$

given by Chandler (following Argelander) may not be applicable. It represents a periodic variation in the period. The observations of S Herculis and R Leonis cannot be represented by such a formula; but they can both be represented by three straight lines, *i.e.* by three uniform periodicities, with abrupt changes of period at the separating dates. It remains to be seen whether the same is true in other cases. Mr. Bellamy made a careful study of the comparison stars near T Herculis, finding one of them possibly variable.

Five more notes on the counts of stars in different zones of the Astrographic Catalogue have been published during the year, including material for the whole of the Cape Zones, kindly supplied by H.M. Astronomer. A definite hypothesis has been formulated that there is a spiral formation of difference between bright stars and faint, not related to the Galaxy, but following approximately the curve $\alpha + 3{\cdot}66\,\delta = 247^{\circ}$. Other counts are being made to test this hypothesis.

A number of new proper motions have been found by the comparison of plates, including some by Miss E. F. Bellamy from comparison of two Vatican plates; some from measures by Mr. M'Neile of Wellington College; and some from measures by

Mr. R. Allen and Mr. Percy, Belgian refugees who have done a large amount of volunteer work at the Observatory.

Mr. R. S. Capon, who had hoped to spend a year at Mount Wilson (taking advantage of arrangements kindly made by Professor Hale), returned after six months and enlisted as a private, was invalided home, and towards the end of the year received a commission, ultimately joining the Flying Corps.

The Coats Observatory, Paisley. (*Convener, Dr. Ferguson.*)

During 1915 the usual work of the observatory—astronomical, meteorological, and seismological—has been carried on with only slight interruptions. Throughout the year the Dines-Baxendell Anemograph has been most satisfactory in its working, and has given a continuous series of interesting and valuable records.

To the great regret of the Committee, their Convener, Mr. John Woodrow, was laid aside by illness in March, an illness which ended fatally on December 19. In the interim two of his colleagues on the Committee, Dr. Ferguson and Mr. John Woodrow, junr., rendered valuable service, and Dr. Ferguson has in course become Convener.

Temple Observatory, Rugby. (*Director, Mr. G. M. Seabroke.*)

This observatory has been used as usual for educational purposes, and the attendance of boys has been good. Mr. Hewlett gives those who like to come an hour's talk while showing objects of interest every fine evening. A few double stars have been measured.

Hill Observatory, Salcombe Regis, South Devon.
(*Director, Sir Norman Lockyer, K.C.B.*)

Observations.—The Rusthall 12-inch prismatic camera has been in use throughout the greater part of the year chiefly for photographing stellar spectra to complete the spectroscopic survey of the northern stars down to fifth magnitude. During the year 335 spectrograms were secured, and the spectra of 285 stars were classified. Ten spectrograms of *o* Ceti were obtained between January 7 and March 1, and four others were taken during December.

The Kensington 10-inch Cooke equatorial, after receiving considerable attention at the makers, was received here and set up during January and February. Messrs. Cooke & Sons also made a metal tube, camera back, and prism mounting for the 9-inch Henry lens and 50° prism, carried by aluminium brackets bolted to the cradle of the 10-inch. On January 21 the 9-inch prismatic

camera mentioned in last year's report was finally dismantled and the lens and prism mounted on the new tube. The installation of the instrument, including the adjustment of the equatorial, was completed early in February and the first trial spectra taken on the 15th. Altogether 71 spectra of various stars down to nearly 4·0 mag. were secured to August 10. Subsequently an 8-inch Grubb prism of 40° angle (lent by the Joint Permanent Eclipse Committee) was mounted in front of the first prism and the prism train covered by a convenient aluminium hood. Forty-four spectra were photographed from August 23 to the end of the year.

Laboratory.—After rearranging the optical train of the grating spectrograph, some spectra of the flame of arc of Ti and Mn, with carbon-arc comparisons, were taken during January. Experimental work, however, was suspended whilst an electric furnace of the carbon-tube resistance type, designed by Dr. J. A. Harker, F.R.S., of the National Physical Laboratory, was being set up, together with the necessary auxiliary apparatus supplied by Messrs. Siemens Bros.

Discussions.—A new catalogue containing nearly 2000 stars assigned to positions on the temperature curve on the basis of the criteria described in Bulletin II. has been prepared for publication. The available data concerning the variable star β Lyræ have been subjected to detailed analysis. The distribution in spectral types of the brighter stars, arranged according to magnitude has been studied both from the Harvard Revised Photometry and the Kensington classification. Spectra of η Leonis and α Cygni taken with the new 9-inch Henry prismatic camera (50° prism) have been measured and reduced.

Publications.—Nos. 2, 3, and 4 of the Observatory Bulletins were issued during the year. They relate to stellar classification, and include a catalogue of 354 fainter stars classified according to a slightly modified Kensington classification. A paper on the oxyhydrogen flame spectrum of iron has been communicated to the Royal Society.

Buildings.—The erection of the Connaught Dome for the 30-inch reflector has not yet been undertaken. All the buildings are in good repair.

Miscellaneous.—Comet 1915 *a* (Mellish) was seen on the morning of March 20. Comet 1915 *e* (Taylor) was observed on December 16. An aurora with streamers was very noticeable on the night of Monday, December 6. Lunar rainbows were seen on March 1 (full moon) and December 16 (three days after first quarter). A 22° lunar halo on November 17 made an interesting sight. At 8 p.m. Jupiter, α Pegasi, and α Andromedæ appeared strung on its inner circumference.

Staff.—Two members of the staff took up military duties during the year, Mr. N. K. Johnson, B.Sc., A.R.C.Sc., resigning on April 15, and Lieut. W. J. S. Lockyer, R.N.V.R., M.A., Ph.D., F.R.A.S., leaving for this purpose on July 15.

Imperial College, South Kensington. (*Professor A. Fowler.*)

The astronomical instruments were used chiefly for purposes of instruction, but occasional observations of solar prominences and of the spectra of Sun-spots were also made. The 5-inch telescope, large grating spectrograph, and other instruments are still detained in Russia; they have been transferred to the care of Dr. Backlund at Pulkovo.

A further study of the band spectrum of helium, previously described by Mr. Curtis, brought out the interesting fact that while the lines constituting the bands are arranged in the usual way, the heads of the bands are arranged in the same manner as the lines in an ordinary line series (*Proc. Roy. Soc.*, A, 1915, vol. xci. p. 208). These bands have not yet been traced in any celestial body.

An investigation of the spectra of various metals, when used as cathodes in vacuum tubes, was made by Professor P. E. Robinson, of Princeton University (*Ap. J.*, xlii. 473).

Mr. E. G. Bilham commenced an investigation of the possible disturbances of the wave-lengths of lines by the presence of closely adjacent strong lines due to other elements. In consequence of Mr. Bilham's appointment to the staff of the Kew Observatory, the work was not carried far, but some results of interest were obtained (*Ap. J.*, xlii. 469).

An investigation relating to the secondary spectrum of hydrogen was interrupted by the appointment of Mr. P. Matthew to the research laboratory at the Royal Arsenal, Woolwich.

Among other spectra under investigation were those of silicon and carbon when subjected to very strong discharges.

A considerable amount of time has been occupied by work connected with the war.

Stonyhurst College Observatory.
(*Director, Rev. W. Sidgreaves, S.J.*)

In our last report we had to record the closing of our radio-telegraphic installation and the consequent interruption of the work with the transit instrument for the correction of our longitude. By favour of the Postmaster-General the use of the installation has been restored to us for the reception of time-signals only, and the instrument is kept under lock and key, so that no one can have access to it without the knowledge of the Director. But the work for the longitude has suffered, as many other works have suffered, by the stress of the great war, the observing assistants being employed in other ways. The self-recording instruments—meteorological, magnetical, and the Milne seismograph—have been kept in continuous action throughout the year.

The Perry memorial 15-inch O.G. equatorial, with the Whitelow

6-inch O.G. camera attached, the Thorp prism equatorial, and the large grating spectrometer have been placed under the direction of Father Cortie, assisted by our Belgian guest Mr. Henroteau; and the following is Father Cortie's report:—

The solar surface has been observed on 257 days, and 255 drawings have been made. The number of days without spots but with faculæ was 9, and on only 2 days was the surface found to be free from spots and faculæ.

The spectra of some of the larger spots, in the region C – D, were photographed with the large grating spectrograph, and on 2 days the spectra of spots were observed visually. There has been no substantial change in the spectra of Sun-spots observed since the year 1882.

With the Whitelow camera a series of spectra of β Lyræ was secured, and a few exposures were made on the spectrum of the nebula in Andromeda. A direct photograph of Comet Mellish (1915 *a*) was obtained on October 4. With the Thorp prism spectra of Sirius, Arcturus, γ Pegasi, α, β, γ Andromedæ, γ Orionis, and β Arietis were photographed.

A good deal of work has been done on the efficiency of Sun-spots in relation to terrestrial magnetic disturbances, and on the convection currents of the solar surface, as evidenced in the drift of the faculæ.

Wolsingham Observatory (Rev. T. E. Espin).

The observation of stars in the selected zones has been continued throughout the year, and the new double stars found in the course of the work have been communicated to the Society.

Mr. A. M. Newbegin's Observatory, Wallington, Surrey.

Observations of the Sun have been continued during the year 1915, and the results of prominence records are again given in tabular form:—

Number of observations	= 133
,, prominences	= 1578
Daily average	= 11·86

These were distributed as follows:—

Prominences on N. hemisphere	= 774
,, S. ,,	= 804
,, E. limb	= 807
,, W. ,,	= 771

Besides these there were 329 prominences below the 30″ standard minimum height adopted for the purposes of the above statistics.

Metallic prominences have been observed on 40 days, and many showed great activity, not only in the number of lines seen but also in displacements of the H_α line.

It will thus be realised that the Sun's activity as compared with 1914 has increased more than twofold, and that the increase, taking the Sun as a whole, is remarkably uniform. Observations of the spectra of the chromosphere and Sun-spots have also been made. During the year a 5-inch Cooke astrophotographic lens has been on loan to the observatory from Mr. Percy Morris. This has been used on several nights on star-fields.

Mr. G. J. Newbegin's Observatory, Sutton, Surrey.

Fifty-eight observations for solar prominences were made during the year 1915. These yielded a total of 449 prominences and a mean daily average of 7·74: of these 324 were classed as bright and 125 as faint.

The Solar Union having adopted 30″ of arc as the minimum height, for statistical purposes, a reduction of 187 is necessary, thus leaving 262 above the specified height. The diagram illustrating the work done here, however, will be built up on the larger figures, thus retaining the same continuity of comparison.

Many interesting features have been noticed in both N. and S. equatorial belts of Jupiter.

Rousdon Observatory, Devon.
(Sir Wilfred Peek's; Mr. C. Grover, Observer in charge.)

The building is kept in good repair, and the instruments are in perfect working order. Weather has been very changeable, with a very heavy rainfall and much dense fog, but observations have been made on 140 nights. September and November were good observing months. Observations of the long-period variable stars were continued on the same lines as in former years, and 408 magnitudes were determined, making a total of 12,867 magnitudes during the 30 years this work has been in progress. 470 maxima and 344 minima have been observed.

Special attention has been given to the long-period variable S Herculis, new elements of which have been computed by the Rev. T. E. R. Phillips (see *Monthly Notices*, vol. lxxv., No. 7, May 1915), who finds two formulæ for the star, giving June 2 and June 9 for the date of maximum. The observed maximum was very close to the latter date.

Observations of stars with the transit instrument are frequently taken for the regulation of the sidereal clock, which maintains a very steady rate. The usual meteorological observations have been regularly continued.

The Rev. T. E. R. Phillips' Observatory, Ashtead.

The usual work on planets was continued, and a number of stars measured with the 8-inch Coleman telescope lent by the Society. Observing conditions were exceptionally favourable on many nights during the thundery weather in August, and a large amount of intricate detail was visible on the surface of Jupiter. The study of the light curves of variable stars has been continued, but various circumstances have limited the amount of work done.

In December the instruments were dismounted for removal to Headley Rectory, Epsom, and the work of their re-erection is nearly completed.

Mr. Reynolds' Observatory, Harborne, near Birmingham.

28-inch Reflector.—During the greater part of the year, owing to pressure of other work, the 28-inch reflector was not employed.

In the autumn of 1915, however, the telescope was rearranged as a Cassegrain, with a convex mirror giving a virtual focal length of 55 feet, the focal cone being brought to the south side of the telescope by a 45° plane mirror. With this arrangement a series of photographs of Jupiter was obtained in November, the image being further enlarged by means of a negative lens, with a resulting equivalent focal length of 180 feet. Transparencies of these photographs have been presented to the Society.

Photomicrometer. — The measurement of the photographic brightness of a large number of points in the Huyghenian region of the Orion nebula has been completed; also a comparison of the stars given in G. P. Bond's catalogue of stars in and around the nebula, with those shown on a negative taken 1915 March at Helwân.

Mr. F. Sargent's Observatory, Eastville, Bristol.

Previous to the year 1915 observations had been conducted here in the open air, using a $10\frac{1}{2}$ reflector.

The receipt, early in the year 1915, of a 5-inch Cooke clock-driven equatorial refractor made the erection of an observatory necessary. This was duly accomplished, and the telescope put into use at the earliest opportunity.

(It seems fitting to mention that the erection here of this excellent instrument is due to the kindly interest and munificence of certain gentlemen who are Fellows of the R.A.S.)

The two instruments mentioned constitute the equipment of the observatory. A micrometer (loaned by the Society) is being fitted to the refractor.

Planetary observation has been the principal work performed.

Jupiter has been consistently observed since early in May. At the time of writing, eighty-eight nights have yielded about

five hundred time-transits of Jovian features, and much interesting data have been gathered. These observations are being continued, and it is hoped that a report will be published in due time.

Venus, Saturn, and Mars are at present engaging attention.

In conjunction with Mr. Denning, an attempt has been made to ascertain the heights of telescopic meteors. Unfortunately, this work has only been possible occasionally. The efforts have not been entirely without results, but more must be done before legitimate claims can be made.

Sweeping for comets has engaged much time. Whilst no discovery has been made, the work has yielded some interesting compensation, and will be continued.

Mr. W. H. Steavenson's Observatory, West Norwood.

The usual observations of planets and comets have been continued, as in former years.

A 15-inch equatorial reflector, mounted in the English style, was erected towards the end of June, and has been in use since July 2.

A number of Struve's pairs, to the components of which their discoverer assigned equal magnitudes, have been observed with a view to the possible detection of their variability. In many instances there exists now a marked difference of magnitude.

Regular observations of Nova (1892) Aurigæ and Nova (1912) Geminorum have been made with the reflector. The former is now of about the fourteenth magnitude and has shown no variations in light. The latter has been fluctuating to the extent of about half a magnitude, its mean magnitude being $12^{\cdot}5 \pm$.

Nova (1901) Persei has been found to be markedly variable to the extent of about one and a half magnitudes. Its mean magnitude has been about $12^{\cdot}5$, and the variations in brightness have been irregular.

Helwân Observatory, Egypt.
(*Superintendent, Mr. H. Knox Shaw.*)

Time-Service.—The time-service has been maintained as usual. The Riefler clock stopped once owing to corrosion of the winding contact, but otherwise has gone very well.

Reynolds Reflector.—The telescope was used on 126 nights, and 182 plates were exposed during the year:—

27 plates on the variable nebula, N.G.C. 6729.
70 „ „ 50 other nebulæ.
18 „ „ stars of large proper motion.
17 „ „ Comet 1915 *a*.
4 „ in search of planet MT (Albert).
23 „ on standard fields for test purposes.
17 Hartmann test-plates.
5 miscellaneous plates.

In addition, ten photographs were taken with the Cooke lens, of which four were of Comet 1915 *a* and two of N.G.C. 6729. Similar photographs were also taken with the prismatic camera.

The driving clock gave considerable trouble in the spring, and although the chief faults have been cured the following is not as good as it should be. Attempts at shielding the mirror from the dust which so quickly spots it have been only slightly successful.

A good series of short exposures of Comet 1915 *a*, which showed the multiple nucleus well, was obtained in May, and these plates have been measured and the results published in Bulletin No. 16. A preliminary note on the variable nebula N.G.C. 6729 has also been published.

Professor Birkeland used the telescope in April in conjunction with his sensitive light-cell, with which he is studying the zodiacal light.

Radiation.—The series of observations with an Ångström pyrheliometer has been continued and extended, both the total radiation and that transmitted by a green screen and water cell having been measured at three zenith distances on 178 days during the year. On 39 of these days in the first half of the year further observations were made nearly continuously throughout the morning. The results for 1914 are in the press. In the discussion of them some interesting points have arisen.

General.—Mr. E. W. Bliss left the Observatory at the end of February, and his place has not been filled. He had assisted in the work with the reflector. Bulletins Nos. 14, 15, and 16 were published during the year. The usual meteorological, seismological, and magnetic observations have been made, with the exceptions that observations of atmospheric electricity have been discontinued, and only one seismograph has been in use. On April 1 the Observatory was transferred with the Physical Service from the Survey Department to the Ministry of Public Works.

Nizamiah Observatory, Hyderabad, Deccan.
(*Director, Mr. R. J. Pocock.*)

During the year steady progress has been made with the astrographic work, though much more would have been achieved had there not been great difficulty in obtaining plates from England, which has caused serious hindrances to the work during the last few months of the year.

Attention is at present being confined to zones 17° and 18° S. Decl. The whole of the standard co-ordinates and other preliminary computations for these two zones have been completed, while 83 plates in zone −17° and 28 in zone −18° have been completely measured, reduced, and copied for press, practically the whole of this work falling in the past year. The total number of stars on these 111 plates is 44,955.

During the latter part of the year some Oxford plates have been measured and compared, with a view to determining proper motions, and the results have been communicated to the Society.

Four lenses belonging to this observatory—including the 15-inch lens belonging to the Grubb telescope—have been lent to the Kodaikánal Observatory, one for use at Kodaikánal and three for use in Kashmir.

Kodaikánal and Madras Observatories.
(*Director, Mr. John Evershed.*)

Owing to the efforts of Dr. Gilbert Walker, Director-General of Indian Observatories, and the representations made by Professor Turner, the Government of India sanctioned a second expedition to Kashmir early in 1915, for the purpose of testing the conditions for solar work over a period of nine months, including the less favourable winter season. Preparations for this expedition occupied much of the Director's time during the first six months of the year: these included the construction of a large spectroheliograph for photographing the Sun's image on a scale of $4\frac{1}{2}$ inches to the diameter. This was successfully accomplished in the Observatory workshop.

The Director is greatly indebted to His Highness the Nizam's government, and to the Director of the Nizamiah Observatory, for the loan of some large lenses, two of which form an indispensable part of the Kashmir spectroheliograph installation.

The work at Kodaikánal Observatory was continued on the usual lines up to the date of departure of the Kashmir expedition in July, and, with slight modification necessitated by the dismantling of the photoheliograph, after that date. The first assistant and the photographic assistant accompanied the Director and Mrs. Evershed to Kashmir, whilst Dr. Royds and the staff remaining at Kodaikánal have ably carried on the work of the Observatory. This now includes daily photographs with two spectroheliographs of calcium and hydrogen solar images, and researches with the large spectrograph, mainly connected with line-shifts in the solar spectrum. Several series of interesting spectra have been secured, using the new Anderson grating: among these is a set of spot-spectra showing a curious new feature in the radial motion effect, and a series showing the displacements of the lines in general sunlight compared with the arc spectrum of iron. These are intended for comparison with the Venus spectrum, when the planet is reflecting light from a hemisphere of the Sun turned 90° or more from Earth.

Dr. Royds has continued his experiments with the electric arc to elucidate the displacements of lines due to the density effect. He has also determined the displacements of the lines of nickel and titanium at the centre of the Sun's disc and at the limb.

The Kashmir expedition reached Srinagar on July 15, and work was begun immediately on the stone piers for the spectro-heliograph and its moving object-glasses (a long-focus and a short-focus lens are used) and the siderostat. A 6-inch Cooke equatorial telescope was also set up in the open, and a grating spectroscope constructed for observation of the prominences. The equatorial was adjusted, and observation of the prominences begun on August 8, and from that date until December 13 an almost uninterrupted series of records was obtained by Mr. Sitaramayyar, only four days being missed owing to cloudy weather. The first spectroheliogram was obtained on September 9, and thereafter H or K images were obtained on all clear days.

Generally speaking, the solar definition may be described as good, especially during the warmer weather in August and September, when it was remarkably uniform from day to day and throughout the day. It was disappointing, however, to find the seeing by no means equal to that experienced in the spring and early summer of 1914; and there was, moreover, a tendency to deterioration as the altitude of the Sun diminished with the advancing season. The inferior definition may probably be due to the abnormally dry weather experienced throughout the summer and autumn: instead of well-irrigated rice-fields and luxuriant vegetation, the entire valley and surrounding hills became parched and bare, exposing the dry soil to the heat of the Sun. It appears that abundant moisture in the valley is a most important factor in producing good solar definition.

Publications.—Bulletins Nos. xlv. to xlviii. were published during the year; also an article on "The Atmospheric Conditions required for Astronomical Observations" was contributed to the Publications of the Astronomical Society of the Pacific, vol. xxvii.

At Madras the time service was maintained as usual.

The Dominion Observatory, Ottawa.
(*Director, Dr. W. F. King, Government Astronomer.*)

Meridian Observations. — Observations with the Meridian Circle were obtained on 121 nights. The total number of transits observed was about 2700, that of zenith distances over 1600; the observations were in the main devoted to the list of latitude stars, upon which work has been carried on for several years. Two observers were engaged throughout the year, and two others for shorter periods.

Telegraphic determinations of longitude, coupled with observations for latitude, were made at three points in Northern Ontario, on the new transcontinental railway line. For the field observations one of the 3-inch Cooke transits belonging to the Observatory, fitted with registering micrometer and latitude level, was used; the longitudes were determined from Ottawa.

Longitudes of seven points in Quebec and two in Ontario,

where no telegraph line was available, were determined by wireless telegraphy. The method used was substantially the same as that described in the last report, the time-signals sent out at 10 p.m. from the U.S. radio station at Arlington, Va., being utilised as intermediaries for comparison of the standard sidereal clock at the Observatory with the sidereal chronometer used for the field observations. The chronometers used as verniers, to effect the comparisons of the wireless signals with the sidereal clocks, were rated to gain about fifteen minutes per day on mean time, as against ten in the previous summer; this was found advantageous on account of the increased number of coincidences obtainable during the five minutes' duration of the wireless signals. Observations for latitude were also made at these stations.

In connection with the operations of the Geodetic Survey, one Laplace station was established in Eastern Quebec. The observations for latitude and longitude were made in the usual way, with a 3-inch astronomical Cooke transit fitted with registering micrometer and latitude level. Observations for the azimuth of one of the lines of the triangulation were made with a Troughton & Simms 12-inch altazimuth. Azimuths were also observed at two stations in Western Ontario.

The time-service has been maintained as in previous years. About 325 electrically driven clocks are operated in the various Government buildings by means of several secondary master-clocks continuously synchronised from the Observatory by the method mentioned in a previous report. In addition, relays beating seconds are maintained in several offices in the city, time-signals are sent out by telegraph and telephone, the time is recorded on the various seismographs, and a time-ball is dropped on Parliament Hill.

Department of Geophysics.—This branch of the activities of the Observatory comprises seismology, terrestrial magnetism, and gravity. The equipment of the three divisions consists of the same instruments as reported in 1912, with the addition of the instrument, now installed in the vault, for the study of the deformation of the Earth under the influence of the Moon and Sun.

Monthly bulletins of the recorded earthquakes are issued as heretofore to about one hundred of the principal earthquake stations of the world. During the calendar year 81 earthquakes have been recorded, being 5 more than the preceding year. Microseisms receive continued attention, and their period correlated with the period of ocean waves obtained by means of the undagraph installed at the lighthouse, Chebucto, near Halifax, and exposed to the open ocean, the Atlantic.

For the first time a mountain-fall has been found to be the cause of a tectonic quake, that of 1911 February 18, in the Pamirs. The mass and height involved were measured or estimated on the spot, and Prince Galitzin quite recently published (*C.R.*, clx. p. 810) the energy involved as $2{\cdot}1$ to 6×10^{23} ergs. There was a good record of this earthquake at Ottawa, and, evaluating its seismogram, the energy deduced was $7{\cdot}0 \times 10^{23}$ ergs,—a quite

satisfactory agreement, considering the uncertainties of absorption factor, density, and velocity of propagation of the long or surface waves.

The magnetic survey of Canada was continued, and 48 stations were occupied, mostly in British Columbia, thereby completing another chain across Canada from Halifax on the Atlantic to Prince Rupert on the Pacific. The stations are approximately 30 miles apart. At each station the three elements—declination, inclination, and intensity—are obtained.

The gravity survey of Canada was continued, completing the first series across the continent from Halifax to Vancouver. During the season 24 stations were occupied with the half-seconds pendulum apparatus. In the reduction of the observations the principle of isostasy is observed, and the method applied by the U.S. Coast and Geodetic Survey is followed. Comparison observations at Washington assure correlation with those in Europe.

Astrophysics.—The work of the 15-inch refractor during the past year has consisted almost entirely of the spectrographic determination of stellar radial velocities, principally of spectroscopic binaries. Very satisfactory progress has been made in this work, as the orbits of 11 binaries have been completed during the year as compared with one during 1914. It must be mentioned, however, that at the beginning of 1915 work on seven of these binaries was well under way. This makes a total of 36 spectroscopic binary orbits determined at Ottawa—more, it is believed, than at any other observatory. The number of determinable spectroscopic binaries within range of the 15-inch telescope is now becoming very small, and it is fortunate that the spectroscopic work can soon be taken over by the 72-inch reflector.

The photographic telescope has been chiefly employed during the year in photometric observations, by the extra-focal method, on several of the spectroscopic binaries observed here.

Observations with the cœlostat telescope and grating spectrograph on the solar rotation and allied problems have been continued during the year. The results obtained from the observations of 1911, 1912, and 1913 are being prepared for publication, and discussed. While there is a small decrease of rotational velocity in 1913, it is not definite enough to indicate a change in the rate of rotation, whose mean daily angular value at the equator for the three years is about 14°·24. However, some observations during the past summer, by a method devised to overcome danger of systematic displacement, showed, in addition to abrupt temporary changes of some 5 per cent. in value, which had previously been noticed, a more gradual cyclic change of the same amount, which may have escaped notice in the earlier observations owing to the short interval over which they extended in each year.

The work on the 72-inch reflector is making satisfactory progress. The pier for the telescope and the walls of the building on which the dome rests are completed. The dome and the telescope mounting, which are both being constructed by the Warner &

Swasey Co. of Cleveland, are well under way, and will be completed early in the new year. The 72-inch mirror has been brought to the spherical form, the Newtonian plane completed, and the Cassegrain, ready for figuring. It is expected that the main mirror will be parabolised and the Cassegrain figured by the time the mounting is erected and ready to receive them.

Adelaide Observatory, South Australia.
(Director, Mr. G. F. Dodwell, Government Astronomer.)

Meridian and Time-Service.—The transit-circle telescope was used throughout the year for the observation of the intermediate standard stars of the Sydney zone (− 52° to − 64°). The observations were reduced from day to day by the aid of graphic reductions, and fundamental stars in the zone were used for the daily time-service. The Time-Ball at the Semaphore was dropped at 1 p.m. daily, except on Sundays and a few other occasions when telegraphic communication was temporarily suspended. An automatic return signal device was installed at the Time-Ball station. The ordinary system of distributing the time to country telegraph stations and various Government Departments was continued.

On November 6 a regular service of wireless time-signals in accordance with the international system was commenced. For this purpose the Observatory was connected by a land line with the Commonwealth Radio Station, about 5 miles distant, and arrangements were made for automatically transferring the Time Signals to the wireless sending circuit. The signals are emitted by Frodsham Mean Time Clock, which simultaneously closes the necessary circuits for setting a tape chronograph in motion and recording on it both the Standard Sidereal Clock beats and the outgoing time-signals. A small electric motor was at first used for sending the warning X*s*; but a suitably cut disc, attached to one of the spindles of the tape chronograph, was found to answer the purpose better. It is estimated that the midnight signals have a range of about 2000 miles and those at midday about 500 miles. They are of special use for ships approaching Australia by the great circle route from South Africa.

A temperature control was installed for the Sidereal clock.

Field Work.—Latitude and longitude stations were established at Gawler, Angaston, and Kapunda, the almucantar method of observation being used, and a complete set of magnetic observations was made at each of those places and at Roseworthy. For the magnetic work a magnetometer outfit, lent by the Carnegie Institution, was used. Results of the longitude exchanges, made in the previous year in connection with the Commonwealth Survey near Port Augusta and Bookooloo on the East-West Railway, were forwarded by the Department of Commonwealth Lands and Surveys. The exchanges were made by both the land line and the wireless methods. The final values were in close

agreement, and the wireless signals were more consistent than those sent on the land line, the latter being subject to a variable lag, due to the length of line and number of repeaters used.

Seismology.—The Milne Seismograph was continuously at work during the year, and the tabulated records were sent as usual to the Shide Observatory, Isle of Wight.

Board of Visitors.—As a result of recommendations made by the Astronomer Royal and Professor Turner and other astronomers who accompanied the British Association for the Advancement of Science to Australia in August 1914, a board of Visitors was appointed in connection with the Observatory. A preliminary meeting of the Board was held on August 27, and Sir J. Langdon Bonython and Professor Kerr Grant were elected President and Secretary respectively. The first visitation was made on November 5. The report read on that occasion has been printed.

Miscellaneous.—Mr. C. A. Maddern, a member of the Staff, enlisted with the Australian Expeditionary Forces and went into camp early in July. He left for the front in December. His position is to be filled temporarily, but no appointment was made in 1915. A report on Magnetic and other observations made on the Musgrave Ranges Expedition has been printed.

The 8-inch Equatorial Telescope was used principally in connection with the regular Friday night visits by the public, and also on certain evenings by members of the S.A. Astronomical Society for variable star and other observations. Some lectures on Astronomy were given at country institutes and other places.

Melbourne Observatory.
(*Dr. J. M. Baldwin, Acting Government Astronomer.*)

Transit Circle.—During the year the following observations have been made with the 8-inch transit-circle, the list stars being from the supplementary list of stars chosen to serve as additional standard stars for determining the constants of the astrographic plates, and the miscellaneous stars for the most part latitude variation stars observed at the request of Mr. Innes of the Union Observatory, Johannesburg.

	No. of Observations.	
	R.A.	Z.D.
Clock stars . . .	426	307
Azimuth stars . .	193	141
List stars . . .	759	750
Miscellaneous . .	107	107
Total . .	1485	1305

Collimation has been obtained 79 times; level, 65; nadir, 140; flexure, 16; and runs, 30 times.

It is hoped that the present list may be completed during the coming year, but the list is still heavy in certain parts, and nearly all the stars still remaining to be observed lie between 14^h and 4^h in Right Ascension.

Authority has been received for the purchase of a travelling wire micrometer for this instrument, and arrangements are being made for its construction.

Astrograph.—The following plates have been secured :—

Catalogue	69
Triple Chart	18
Kapteyn Areas	6
Pole	30
Comets	9
Adjustment	11
Rejected	27
Total	170

The catalogue plates have been taken to replace plates which it had been found desirable to reject for various reasons; half of these plates were rejected because the réseau used was no longer available for the determination of réseau error. The missing réseaux, of which there are two, had both been ruled in this Observatory, and it is probable that the errors were by no means negligible.

The plates of comets include 5 of Comet Delavan 1913*f* and 1 of Comet Mellish 1915*a* for position. A long spell of cloudy weather allowed of only 3 plates of Comet Mellish being taken after the peculiarity of the nucleus had been detected visually in the 8-inch equatorial.

In March the angles between the axes of the telescope, which had been several minutes in error, were corrected.

A mounting is in course of construction with which the 6-inch doublet will be used with the $4\frac{1}{2}$-inch refractor as guide telescope. The form of mounting allows of complete circumpolar motion, and the guide telescope can be used on objects two degrees away from the centre of the plate. Where possible the work is being done in our own workshops.

The 8-Inch Equatorial.—This has been used for observations of comets as under :—

Delavan 1913*f*	6 nights.
Mellish 1915*a*	7 ,,

Reduction of Meridian Observations.—The computation of the reductions from observed to apparent and from apparent to mean places for 1914 is almost complete.

The proof-sheets of the General Catalogue 1890 have been received from the printer, corrected, and returned.

The first six hours of the General Catalogue 1900 have been completed and the MS. prepared for the printer.

Measurement and Reduction of Astrographic Plates.—Twenty plates for the Astrographic Catalogue, containing 16,242 stars, have been measured. Fifty plates taken during the year remain to be measured to complete the Melbourne zones.

The reduction of the measured co-ordinates to millimetres, and the application of the réseau corrections, have been completed from $-65°$ to $13^h\ 20^m$, $-70°$.

The measured co-ordinates and diameters have been copied on forms for the printer for zone $-65°$ and for zone $-66°$ to $19^h\ 12^m$.

The identification of C.P.D. stars has been completed for zone $-65°$ to $13^h\ 57^m$.

The comparison of the positions of stars as given by plates in the neighbouring zones $-65°$ and $-66°$ has been started, and has proceeded as far as 10^h.

At the request of Professor Turner of Oxford, a count of stars according to diameter was made for zone $-65°$. In the course of this count it was found that there was a very serious discrepancy between the diameters on plates measured with two of the machines (Micrometric and Comb) in the early part of the work, and later measures made on the Repsold instruments. In consequence of this the whole of the diameters measured with these two machines have been rejected, and are being remeasured on one of the Repsold machines. This work is now complete for zones $-65°$ and $-66°$.

The Reduction of Observations of Comets made during 1915 is almost complete, and the results will shortly be forwarded for publication. Orbit elements and ephemerides of Comets Campbell-Westland and Mellish 1915*a* were computed by Mr. C. J. Merfield, and have been published.

Magnetic Observations and Reductions.—Observations for the determination of the absolute value of the Earth's field were recommenced in October, and are being taken fortnightly.

The Adie recording instruments were thoroughly overhauled in December, and the sensitiveness of the H and Z instruments changed from 11 and 50 γ per mm. to 4·7 and 7·9 γ per mm. respectively. It was thought desirable not to further increase the sensitiveness of the Z component, as the effect of the electric tramways keeps the balance in continuous oscillation during the whole time the trams are running. This is much more noticeable in the Z than in the H component. The question of moving the magnetic Observatory to some undisturbed station is now very urgent, particularly in view of the coming electrification of the suburban railways, which at their nearest point approach within 5 furlongs of the Observatory and which extend 290° round the Observatory within $1\frac{1}{2}$ miles. The nearest electric tramway at present in operation is 1 mile away.

Owing to lack of assistance very little progress with the reduction of the curves has been possible during the year.

Seismograph.—Records have been taken as usual, and a number of these have been read off; but this work has had to be discontinued during the latter part of the year. The reading

off will recommence with the new year, and back curves will be done as opportunity arises.

Time-Signals have been sent as usual. The service now consists of:

(1) Automatic signals in accordance with the international code from the Observatory through the neighbouring wireless station daily at noon and midnight, corresponding to 2 a.m. and 2 p.m. Greenwich mean time.
(2) Signals to the time-ball at Williamstown and that at Hobart (Tasmania) and to the telegraph offices throughout Victoria at 1 p.m. daily (Sundays and certain holidays excepted).
(3) Signals each second to the railway offices.
(4) Time by telephone on request. Time is given each day to the tramways (cable and electric), and the service is made use of largely and to a constantly growing extent by the public.

In November the Standard Clock Frodsham 991 was dismounted for cleaning and slight changes. The opportunity was taken of re-erecting it in an underground room where the conditions are much more favourable, and at the same time the Mean Time Clock, which serves for sending time-signals, the performance of which had lately been very unsatisfactory, was thoroughly overhauled and re-erected in the position previously occupied by Frodsham 991, which was much better than its old position. The cause of the erratic performance appeared to be that some of the screws connected with the system of springs for the wireless signals had become rusted, and undue work had to be done by the clock. The performance of Frodsham 991 has been very good since its re-erection, and the Mean Time Clock also gives promise of a better record.

The registration of the tides at Williamstown, the testing of weights and measures, the rating of chronometers, and other miscellaneous services have been carried out as usual.

The practice of admitting visitors on three nights in each lunation, and on Wednesday afternoons, has been continued.

Personal.—Mr. P. Baracchi, who has been in charge of this Observatory since 1895, resigned his position as Government Astronomer on August 31; Dr. J. M. Baldwin, Chief Assistant, was appointed Acting Government Astronomer from September 1.

Three young ladies employed in the astrographic bureau, and one in the reduction of magnetic work, have resigned during the year, a clerk has been transferred to another State Department, and a junior assistant has been absent on sick leave since November 12. No fresh appointments have been made, so that the staff of the Observatory during the last months has been seriously reduced. In consequence, the reduction of the magnetic records has had to be discontinued for the present, but absolute observations and observations for scale value will be made as

before indicated. The rate of preparation of the Astrographic Catalogue has been greatly retarded; the work on the Catalogue of Standard Stars, however, has not up to the present been interfered with.

Perth Observatory, Western Australia.
(*Director, Mr. H. B. Curlewis, Acting Government Astronomer.*)

Meridian Observations.—It was again deemed inadvisable to make a start on the list of "intermediate" stars, but to concentrate the energies of the small staff upon the Astrographic Catalogue work, the completion of which is of the first importance. Besides, the "intermediates," with the exception of a few new stars extracted from the list of standards compiled by the Committee appointed at the Paris Conference of 1910, have already been observed and published (vols. i.–vi. *Meridian Observations*), and a couple of years' delay will make little difference. The work on the Transit Circle was therefore confined solely to time observations, which occupied 165 nights.

Astrographic Catalogue.—The decision to keep the measuring and computing staffs engaged solely upon the Astrographic work has been abundantly justified, the close of the year seeing zone 36° fully completed, while more than half the measures of zone 37° have been finished. This progress is very satisfactory, and is largely due to the personnel of the staff having remained unchanged for several years. Provided nothing untoward takes place, the remaining zones should be completed in a couple of years.

The number of plates measured during the year was 145, containing over 68,000 stars, while 106 were taken, of which 27 were rejected. Vols. ix.–xii., containing the measures of zone 34°, were distributed during the year.

Seismology.—The Milne seismograph registered satisfactorily during the year. Mr. Yeates, upon whom the care of this instrument devolves, effected improvements in the lighting and also the time-registering apparatus attached to the instrument, whereby a more distinct mark is made every hour. During the twelve months very few earthquakes were recorded—the year standing as a record in that respect. The boom was violently disturbed on only five occasions, moderately on six, and slightly on fourteen, faint tremors or thickenings of the trace occurring.

Tidal.—During the year the predicted tide curves for Port Hedland for 1916, based on the constants derived from the analysis of the 1913 hourly records, were received from the Superintendent of the United States Geodetic and Survey Department. The figures extracted from these curves were published and distributed towards the end of the year. Beyond this the tidal work remains in abeyance, but it is hoped that a re-start will be made shortly, for a more exact knowledge of the tides, especially of the N.W. and N. coasts of Australia, is very desirable.

Time Service.—The time-ball at Fremantle failed 9 times in June, owing to some radical fault on the line. After this had been fixed up early in July, only 4 failures occurred, 3 due to breakage of the line by heavy weather and 1 to non-hoisting of the ball. The automatic check upon the time of ball-drop is still maintained, and showed that on only a few occasions did the error exceed a tenth of a second.

The method of disseminating the time throughout the State remains the same as in the past, but there is an ever-growing demand for the correct time by telephone, which is very gratifying and shows that this necessary function of the Observatory is appreciated by the general public. The arrangements for connecting the Observatory with the wireless station at Applecross have not yet been completed.

Miscellaneous.—The partial solar eclipse of February 14 was observed and several photographs were obtained. Readings of the solar maximum thermometer showed that the temperature dropped from 102°·6 at 11.43 a.m. to 79°·4 at 12.10 p.m. (1 minute after mid-eclipse), and rose subsequently to 141°·3 at 1.41 p.m. (end of eclipse).

Comet 1915*a* (Mellish) was observed, but only a few photographs were taken owing to cloudy and wet weather. This was very unfortunate, as the disruption of the nucleus made a continuous series most desirable.

As an outcome of the difficulty experienced with the slow motion in Declination, Mr. Yeates made a new one, a description and photograph of which appeared in the *Western Mail.*

The number of day and night visitors to the Observatory was greater than usual, nearly every Tuesday afternoon being engaged, and 93 evenings. The demand for astronomical lectures has considerably increased, and entailed a great deal of work, for in almost every case they were illustrated by lantern slides made from photographs taken with the Astrograph. It was found that the local touch introduced thereby gave added interest to the lectures. The usual information was given to the press. The Western Astronomical Society, with its headquarters at the Observatory, still maintains its popularity.

Sydney Observatory.
(*Director, Mr. W. E. Cooke, Government Astronomer.*)

The most important event in connection with this Observatory during 1915 was the preparation of plans for the new buildings to be erected at Wahroonga. These are now in a forward state, and it is hoped that the work of construction will shortly be commenced.

Routine work proceeded as usual, both at the Observatory and the University, but real scientific progress is of course still impracticable until the long deferred reorganisation is effected.

Owing to the war, no further developments in connection with wireless time-signalling were possible on account of military regulations, but a fair amount of experimental work has been carried out.

Union Observatory, Johannesburg.
(Union Astronomer, Mr. R. T. A. Innes.)

Instrumental Equipment.—This remains virtually unchanged. A photographic enlarger was obtained late in the year, with which it is purposed to reproduce a map of the southern sky on a scale of $1' = 1$ mm. (astrographic scale).

9-inch Refractor.—Measurements of double stars have been continued, and during the year satisfactory sets have been obtained on at least two nights of 310 pairs. Mr. Voûte's list has already been published, and the remainder will appear in Circular No. 33, now in the hands of the Government printer.

The phenomena of Jupiter's Galilean satellites have been observed regularly. A comparison of the whole series (1908 to date) with Sampson's Tables is nearly completed.

Comets (Delavan) 1913 *f*, (Mellish) 1915 *a*, (Winnecke) 1915 *b*, and 1915 *e* (Taylor) were assiduously observed, and the results are despatched promptly to the Government printer for publication.

Miscellaneous observations such as observations of nebulæ and variable stars, occultations of stars by the Moon, a near approach of Mercury to Spica, etc., were also made.

$2\frac{5}{8}$-inch Talcott Telescope.—This has only been used for time-service. Latitude observations were discontinued in December 1914. During the year the late Professor Albrecht published a first discussion of the observations made here, in a paper entitled "Ergebnisse der Breitenbeobachtungen auf dem Observatorium in Johannesburg vom März 1910 bis März 1913." He arrives at the conclusion: "Das Resultat dieser Beobachtungsreihe ist hiernach eine wertvolle Bestätigung dafür, dass man die Beobachtungsresultate auf der Nordhalbkugel ohne weiteres auch auf die Südhalbkugel übertragen kann."

Franklin-Adams Twin Telescope.—Spectrograms of bright stars on panchromatic plates have been obtained. A selected list of variable stars was observed.

Franklin-Adams Star-Camera.—Exposures have been made on selected regions of the sky for minor planets, variable stars, and stars showing proper motion. Photographs were obtained of Comets Delavan, Mellish, Winnecke, and a new comet discovered by Taylor at Capetown on 1915 November 22. A preliminary orbit for this comet was computed and cabled to Greenwich. With the 6-inch guiding telescope visual observations were made of the phenomena of Jupiter's satellites, of the variable R Normæ, and of occultations of stars by the Moon.

Observatory Circulars.—Nos. 22 to 32 were actually distributed in 1915. On account of the necessity for strict economy, these circulars await convenient moments for printing in the Government printing-office; there is therefore sometimes an enforced delay of about three months between the despatch of the MS. and the issue of the printed circular. The chief contents of these circulars are:—No. 23, Observations of Jupiter's satellites and a comparison of the eclipses of Satellite I. during 1909–1911 with Damoiseau's and Sampson's Tables; it is here sufficient to remark that Damoiseau's Tables show up better than might have been anticipated; Nos. 24 and 27, Measures of southern double stars; Nos. 25, 28, and 30, Proper motions found and measured with the blink-microscope. The following large proper motions were disclosed, besides many other smaller proper motions:—

Star.	Photogr. Mag.	1875.		Proper Motion.
		α	δ	
		h m s	° ′	″ °
−42 4101	8·4	9 46·0	−42 54	0·65 to 131·2
Anon.	12·0	14 21·0	−62 8	5·10 ,, 283·8
−46 8446	9·7	17 3·1	−46 23	0·77 ,, 180·0

In these circulars (especially in No. 28) the essential economy of the blink-method is insisted on, evidence being advanced to show that what is wanted is not bulky catalogues of the astrographic co-ordinates of stars, but astrographic charts which convey far more information in a less bulky form; that on the whole, even when completed, the astrographic catalogues will only afford a distorted view of the sidereal universe, because they are limited to a one-sided selection of some 3,000,000 of the 50,000,000 stars which will be charted. The question really put in Circular 28 is whether the completion of the astrographic catalogue is worth while, and whether it would not be preferable to concentrate on the reproduction of the charts in a permanent form, as is done by the Tacubaya Observatory. Circulars 26 and 31 continue the previous "blink" examinations of the regions near η Argûs and Corona Australis for the detection of variable stars. No. 29 contains an extended table for the conversion of right ascension and declination (1900) to a strictly invariable system of galactic co-ordinates. A reference list of the best photographs obtained with the Franklin-Adams star-camera in 1914 is given in circular No. 25.

Time-Service, Meteorological and Seismological Observations.—These have continued unchanged. The large number and increasing force of the local earthquakes caused by mining operations near Johannesburg led to the appointment of a committee of inquiry, the Union astronomer being nominated as one of the members. During the year 893 shocks, due to local causes, some of which were sufficiently violent to cause alarm, were registered.

Staff.—Mr. Van der Spuy having been appointed a flight captain, has finally left the Observatory. Mr. E. L. Johnson was

absent during the German South-West African campaign, and has been passed for the German East Africa Expedition. Mr. W. M. Worssell has taken vacation and special leave to join the army in Europe. Mr. H. E. Wood has been temporarily rejected by the medical authorities. Thus at present the staff is reduced to Mr. Innes and Mr. Wood, with two lady assistants who do the clerical and meteorological work. Mr. Innes observes with the 9-inch refractor, and Mr. Wood is now charged with the time-service in addition to his work with the Franklin-Adams star-camera. It follows that the time which can be given to research work is greatly reduced.

Lovedale Observatory, South Africa. (*Dr. Alex. W. Roberts.*)

As in former years, the work of this Observatory has been confined to the observation of variable stars south of $-30°$ Declination. The light changes of many of these stars have now been observed continuously for twenty-five years, and thus important data have been secured for a determination of secular change in period and amplitude of variation.

The number of observations secured during 1915 is as follows:—

Long-period variables	(70 stars)	2476 obsns.
Short-period variables	(23 ,,)	740 ,,
Algol variables	(8 ,,)	223 ,,
		3439 obsns.

Besides these observations the photometric brightness of over 2000 comparison stars has been determined.

I have to acknowledge with deep indebtedness the continued loan of the Harvard photometer.

Values taken with this instrument, when connected with determinations depending on limiting apertures and corrected by the method of visual sequences, will, I think, yield absolute magnitudes of considerable accuracy.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1915.

The following list of 74 planets includes some discovered in 1913, 1914, of which the details were not to hand at the date of the last Report.

Letter and Number.	Date.	Discoverer.
	1913.	
k	July 27	M
l	Sept. 27	,,
m	27	,,
n	27	,,
o	Nov. 1	,,
	1914.	
a	Jan. 22	M
b	Nov. 24	B
c	21	Pe
VX	Sept. 20	N
VY	22	,,
VZ	Oct. 12	,,
WA	12	,,
WB	14	,,
WC	16	,,
WD	16	,,
WE	16	,,
WF	Nov. 24	,,
WH	25	,,
	1915.	
WL	Jan. 20	W
WM	18	T
WN	Feb. 5	W
WO 799	Mar. 9	R
WP 800	20	W
WQ 801	20	,,
WR 802	Mar. 20	W
WS 803	21	P
WT 804	20	S
WV	Apr. 12	T
WW 805	12	W
WX 806	18	,,
WY 807	18	,,
WZ	17	T
XA	10	,,
XB	May 11	R
XC	Apr. 6	S
XD	May 15	,,
XE	Feb. 14	N
XF	15	,,
XG	15	,,
XH	15	,,
XJ	Mar. 18	B
XK	23	,,
XL	Apr. 18	T
XM	May 12	N
XN	12	,,
XP	Aug. 11	W
XQ	Sept. 8	,,
XR	8	,,
XS	9	,,
XT	9	,,
XU	Sept. 10	W
XV	11	,,
XW	12	,,
XX	2	N
XY	Oct. 2	W
XZ	Sept. 30	T
YA	Oct. 10	W
YB	15	,,
YC	15	,,
YD	15	,,
YE	15	,,
YF	15	,,
YG	10	,,
YH	9	D
YJ	Feb. 18	Pe
YK	Nov. 25	T
YL	25	,,
YM	25	,,
YN	26	W
YO	26	,,
YP	26	,,
YQ	27	,,
YR	28	,,
YS	8	S

The letters stand for:—

B = S. Beljawsky, Simeis Observatory, Crimea.
D = G. Demetrescu, Bucharest.
M = Dr. J. H. Metcalf, Winchester, Mass.
N = G. Neujmin, Simeis Observatory, Crimea.
P = Dr. Palisa, Vienna.
Pe = Mr. George H. Peters, Naval Observatory, Washington.
R = K. Reinmuth, Königstuhl Observatory, Heidelberg.
S = J. Comas Sola, Barcelona.
T = Dr. Thiele, Bergedorf, Hamburg.
W = Professor M. Wolf, Königstuhl Observatory, Heidelberg.

The following planets have received permanent numbers since the date of the last Report: 1907 ZC 792, 1907 ZD 793 (these two were numbered after their recent recovery), 1914 VB 794, VD 795, VH 796, VR 797 (this is 1898 DZ), VT 798.

The following identities have been established: 99 Dike = 1915 WJ (this planet has been missing since 1868), 193 Ambrosia perhaps = 1915 XU, 365 Cordoba = 1914 VN, 392 Wilhelmina = 1914 WG (this planet has been missing since 1894), 468 Lina = 1915 XO, 490 Veritas = 1914 VS, 493 Griseldis = 1915 WK (this planet has been missing since 1902), 495 Eulalia = 1906 WV, 572 Rebecca = 1915 WU (this planet has been missing since 1905), 799 = 1907 YO, 800 = 1912 OM, 804 = 1903 NE (this planet has been named Hispania); 290 Bruna and 594 Mireille (not seen since 1890, 1906 respectively) have been recovered. This recovery of several long-missing planets is a satisfactory feature of the year's work.

The planet 1913 RU should be struck out as erroneous.

A. C. D. C.

Comets in 1915.

Delavan's Comet (1915 *f*) was still an easy object at the beginning of the year. It was followed at the Union Observatory, Johannesburg, till August 30—621 days after discovery,—when it became too faint for visual micrometrical measures. It was then about 15″ in diameter. Later observations were probably made elsewhere, but are not yet published.

Comet 1914 *a* (Kritzinger) was still under observation in January photographically, but it was as faint as 17^{m}. Comet 1914 *e* (Campbell) was photographed at Bergedorf on February 16.

In 1915 two periodic comets were due to return, viz. Winnecke's Comet and Tempel's second periodical Comet, both of which were observed. Mention may also be made of Swift's second periodical Comet (1889 VI.), for which an elliptical orbit was found, and which, it was thought, might return in 1915.

Nothing was seen of it, and it has not been recovered since its first appearance in 1889.

Comet 1915 *a*.—The first new comet of the year was found by J. E. Mellish at Madison, Wisconsin, U.S.A., on February 10. It was then a small object of about 9^m, and was situated in Ophiuchus. Its subsequent path lay in Serpens, Sagittarius, Indus, Toucanus, Hydrus, Dorado, Pictor, Columba, Canis Major, the boundaries of Lepus, Orion (passing near Rigel on November 6), and Eridanus; and at the end of the year it was in the southern part of Taurus. Perihelion was passed on July 17 at a distance from the Sun of slightly over a unit. The closest approach to the Earth—a little more than a third of a unit—occurred near the beginning of June, with the comet finely placed for southern observers. During the second week in June it was between 15° and 20° from the pole. On its return northwards it was seen by Millosevich at Rome on September 4, and was subsequently followed by a number of observers, being still an easy telescopic object at the close of the year.

In physical appearance and behaviour the comet, though not of the first class, was a conspicuous naked-eye object. It had a tail some few degrees in length, which was divided photographically into two main streamers with indications of others, but the most interesting feature presented by the comet was the throwing off from the main nucleus of a number of subsidiary nuclei, such as was observed to happen with the great comet of 1882, Brooks's Comet of 1889, and the lost comet of Biela. On May 12 Professors Barnard and Sullivan, with the 40-inch refractor at Yerkes, found two round condensations in front of the nucleus, and in line with it, all being involved in the nebulosity of the head. Flagstaff photographs showed the subsidiary nuclei to be receding from the main nucleus, while on plates taken with the astrographic telescope of the Sydney Observatory on June 5, 6, and 8 there are as many as four detached nuclei, and changes are traceable in the brightness and form of the coma. The four nuclei were also photographed at the Union Observatory, Johannesburg, on June 10, but they lay on a line not passing through the centre of the head but almost tangential to the coma on its *s.p.* side and directed towards 228°·8. Three nuclei, also not in line with the centre of the head, were found on a Stonyhurst photograph as late as October 4. (*M.N.*, vol. lxxvi. 2, p. 90.)

Photographs of the spectrum taken at Helwân in April show a bright line at λ 388, a broad band at λ 467, and a faint line at λ 404. Professor Lowell found the usual bright bands with a relatively intense background of the solar spectrum, but adds that the group about λ 400 extended further from the nucleus and was brighter than in most comets, while those of the hydrocarbons were relatively fainter. He states further that the cyanogen bands were somewhat abnormal, and that the spectrum should be followed throughout the comet's long period of visibility, but no further particulars are apparently yet published.

It has been pointed out that there is some resemblance between the elements of this comet and those of Comet 1748 II., which, however, was observed on three days only.

Comet 1915 *b* was a return of Winnecke's Comet, a member of the Jupiter family and discovered by Pons in 1819. It was first detected photographically by Thiele at Bergedorf on April 4, when it was as faint as 16^m. Its perihelion passage was on September 1, and its closest approach to the Earth on September 24; but being then more distant than the Sun, it remained throughout its apparition a feeble object. Circular No. 32 of the Union Observatory, Johannesburg, describes it as of 12^m on November 8, and 20″ in diameter. Its path lay in Leo Minor, Leo, Virgo, Libra, Scorpius, Telescopium, Corona Australis, Sagittarius, etc., but few observations are as yet published.

Comet 1915 *c* was a return of Tempel's second periodic comet, another member of the Jupiter family, and first seen in 1873. It was detected by Delavan at La Plata on May 16, after having been unobserved at the 1910 return. When found it was close to the place given in Braae's ephemeris, computed from Maubant's elements for the latter year. Its path after discovery lay in Cetus, Taurus, and the N.E. part of Eridanus, but it had passed perihelion on April 13. It was a faint object, and few observations of its physical appearance are yet to hand.

Comet 1915 *d* was found near the boundary of Leo and Leo Minor on September 13 by J. E. Mellish, who had already discovered the first comet of the year and Comet 1907 V. It was at first a morning object, but it travelled rapidly S.-eastwards on the far side of the Sun and became an "evening star" near the end of the first week in October. It made its closest approach to the Earth ($1\frac{1}{3}$ unit) about the same time. Perihelion was passed on October 13, at a distance from the Sun of rather less than half a unit. Travelling rapidly southwards, its path to the end of the year lay in Virgo, Libra, Scorpius, Telescopium, and the S. part of Sagittarius and Indus. Few observations are yet published, but the comet does not appear to have presented any features of special interest.

Comet 1915 *e* was discovered by C. J. Taylor at the Cape on November 22. It was then a faint object of about 10^m, not far from δ Orionis, and was travelling N.-westwards. The latest orbit published—that of J. Braae and J. Vinter-Hansen—is elliptical, with the date of perihelion 1916 January 30·7, and period 6·29 years. It is therefore another member of the Jupiter family It brightened considerably after discovery, and at the end of the year showed a slight tail.

Among the papers bearing on cometary astronomy published since the last report may be mentioned the following:—

In *A.N.*, 4786, Van Biesbroeck gives hyperbolic elements for Delavan's Comet (1913 *f*) with $e = 1{\cdot}0001788$.

In *A.N.*, 4790, K. Lous discusses the suggested connection between Comet 1896 VII. (Perrine) and the lost comet of Biela. The two orbits are almost in the same plane, and intersect at two

points; but the perturbations of the former comet by Jupiter in 1888 are found to be not very great, and no epoch can be traced at which the two comets were together at either point.

In *A.N.*, 4804, C. Wirtz discusses the available observations of Comet 1766 II. which was discovered by Helfenzrieder at Dillingen in Bavaria on 1766 April 1. It became a conspicuous object of about 2^m, with a tail some 7° in length, and was the brightest of the comets belonging to the Jupiter family. The elements deduced as most probable give April 27 as the date of perihelion passage. Apart from the perihelion distance the elements resemble fairly closely those of Comet 1886 IV.

In *A.N.*, 4806, the same writer finds parabolic elements for the comet discovered by Bradley on 1755 September 12, and he compares with these the elements of the meteor orbit associated with the radiant Sawyer 22 computed by O. C. Wendell. The agreement is fairly close, and a connection between the comet and meteor stream is not improbable.

In *B.A.A. Journal*, vol. xxv. 6, the Rev. M. Davidson points out that only two comets since 1892 appear to have approached near enough to the Earth's orbit to make meteor showers from their debris possible, viz. 1900 III. (Giacobini) and 1906 V. (Kopff), which was an apparition of Finlay's Comet 1886 VII. In the former case the meteor radiant would be at 267° + 50° about October 10, which is in fairly good agreement with a radiant observed by Denning about that time of the year. The latter, however (*B.A.A. Journal*, vol. xxv. 7), considers the connection uncertain, as meteors are to be seen shooting from the same position at various other periods of the year. There is no meteoric shower at present known which can be connected with Comet 1906 V. (Kopff).

H. E. Wood gives the following orbit of Comet 1914 *e*, based on three normal places deduced from the Cape and Johannesburg observations between September 20 and October 24 (*Obs.*, No. 484):—

$T = 1914$ Aug. 5·00630, G.M.T.
$\omega = 270°\ 24'\ 38''{\cdot}8$
$\Omega = 0°\ 22'\ 33''{\cdot}4$ } 1914·0
$i = 77°\ 51'\ 14''{\cdot}7$
$\log q = 9{\cdot}8532157$

The following definitive elements have been published during the year:—

Westphal's Comet. By M. Viljev (*Obs.*, No. 485).
$T = 1913$ Nov. 26·30659, Berlin M.T.
$\omega = 57°\ 3'\ 45''{\cdot}54$
$\Omega = 346°\ 47'\ 23''{\cdot}05$ } 1913·0
$i = 40°\ 52'\ 3''{\cdot}79$
$e = 0{\cdot}9197064$
$\log q = 0{\cdot}0983472$
$\mu = 57''{\cdot}47886$
Period = 61·728 years

Comet 1906 VII. (Thiele). By E. Waage (*A.N.*, 4780).

T = 1906 Nov. 21·2636317, Berlin M.T.

ω = 8° 37′ 30″·42	Mean Ecliptic and Equinox, 1906·0	ω' = 35° 26′ 35″·29	Mean Equator and Equinox, 1906·0
Ω = 84° 47′ 55″·14		Ω' = 70° 45′ 16″·35	
i = 56° 23′ 21″·31		i' = 61° 27′ 35″·07	

$\log q = 0·0837482$

$e = 0·9826245$

$a = 69·792$

Period = 583·06 years

Comet 1890 III. By S. Ogura and H. Kaneko. Comet discovered by Coggia at Marseilles on 1890 July 18 (*A.N.*, 4786).

Hyperbolic Orbit.	Parabolic Orbit.	
T = 1890 July 8·589299, Berlin M.T.	July 8·57448·6, Berlin M.T.	
π = 99° 59′ 21″·37	99° 57′ 22″·20	1890·0
ω = 85° 41′ 23″·78	85° 39′ 18″·71	
Ω = 14° 17′ 57″·59	14° 18′ 3″·49	
i = 63° 19′ 25″·90	63° 20′ 14″·61	
$\log q$ = 9·88333000	9·8831428	
e = 1·0018946		

The probable errors are larger for the hyperbolic orbit, but the sum of residuals is a little greater for the parabolic orbit.

Comet 1909 I. (Borelly-Daniel). By Luigi Gabba (*Pubblicazioni Reale Osservatorio di Brera, Milan*, No. lii.). Computed from seven normal places based on all available published observations from June 16 to August 19.

T = 1909 June 5·32998, Berlin M.T.

ω = 5° 4′ 54″·0	Mean Ecliptic and Equinox, 1909·0
Ω = 305° 41′ 3″·0	
i = 52° 5′ 19″·2	

$\log q = 9·926081$

In consequence of the war the Bureau for astronomical telegrams has been removed from Kiel to Copenhagen, and is conducted by Professor Strömgren.

Erratum.—In the note on Comets in the last Council report (vol. lxxv., No. 4, p. 313) the closest approach of Encke's Comet (1914 *d*) to the Earth is erroneously stated to be 1·9 units. The correct value is a little less than 0·3 unit. T. E. R. P.

Solar Activity in 1915.

Sun-spots.—The revival of activity which commenced, as noted in the Council Report last year, with the appearance on 1914 March 30 of a fine stream of spots at the east limb of the Sun, developed yet further in a striking degree during 1915.

The record for the year divides itself naturally into three distinct periods. There were, first, three months of moderate activity, during which several important groups were seen, but between these centres of activity there were wide regions destitute of spots. Next, a period of great disturbance set in and lasted for nearly five months, during which time important spots tended to become more numerous and to attain greater area and extent. The outbreaks were also more equally distributed in longitude round the entire Sun. Third, the last four months of the year formed a period of more moderate activity, the spot-groups seen being of smaller size and less subject to violent change.

The most important disturbances of the year were the following:—A great group, first seen at the east limb on 1915 March 29, which began the period of greatest activity. This was in the northern hemisphere and persisted during three successive rotations. A magnificent stream of spots was also seen in the northern hemisphere in the month of June, crossing the Central Meridian on June 21. In July three groups, easily seen with the naked eye, were under observation, all three being in the southern hemisphere. The last and most remarkable of the three came into view on the east limb on July 29, passed the Central Meridian on August 4, and had disappeared at the west limb on August 11. It decayed rapidly after passing the Central Meridian, but during the first week that it was observed the mean daily spotted area of the Sun exceeded 2000 millionths of the visible hemisphere.

It is important to note as bearing upon the question as to how far the present cycle has progressed towards its maximum, that whereas there were 142 days without spots in 1914, there were none in 1915. Further, it is usual for the northern hemisphere to hold the predominance in spotted area up to the time of maximum, and for the southern to prevail from maximum until the first harbingers of the new cycle begin to appear. During the early part of 1915 the northern hemisphere was the more prolific of the two, but in July and August, and again in December, the advantage had passed very distinctly to the southern. There is, of course, in the development of every cycle a time during which the balance of activity oscillates between the two hemispheres, and the distribution of the spot-groups of 1915 seems to show that this is the stage to which the current cycle has now advanced.

The appearance during the year of one or two groups, close to the equator, seems to confirm the impression that the cycle has reached an advanced stage of development in an unusually short space of time after the close of the preceding minimum.

E. W. M.

The Prominences.—A large increase of prominence area is shown in the Kodaikánal photographic records for the year

1915. The mean daily areas in square minutes of arc are as follows:—

	North.	South.	Total.
1915 January to June	2·59	2·68	5·27
July to December	2·62	2·67	5·29

The corresponding totals for 1914 were 2·93 for the first half, and 3·34 for the second half of the year.

The numerical estimate of prominences shows, on the other hand, a slight reduction compared with 1914, the mean daily frequencies being 20·5 in 1914 and 19·1 in 1915. The average size of the prominences has therefore greatly increased.

The increase in area is mainly in the region between the equator and latitude 30° north and south, but the higher latitudes up to 60° show also a slight increase. The distribution in latitude has undergone some change during the year: in the first six months there was almost uniform activity from the equator to latitude 45° north and south, increasing from about this point to a zone of maximum activity between latitude 50° and 60°; during the second half of the year the maxima are found in nearly the same latitude in both hemispheres, but they are sharply separated from the mid-latitude prominences by zones of relatively small activity between latitude 40° and 50°. The mid-latitude prominences between 20° and 40° have meanwhile increased to such an extent as to rival the high-latitude zones. The regions between 70° and the poles have been inactive throughout the year, excepting for the production of small and transient jets. The general distribution for the second half of the year closely resembles that found for the year 1903 (two years before Sunspot maximum).

The proportion of prominences found on the eastern side of the Sun's axis was 49·5 per cent. of the whole number, and the areas show a slightly greater western excess. The remarks made in last year's report, vol. lxxv. p. 319, are therefore borne out by this year's results, and an end seems to have been reached of the long series of years showing an eastern preponderance. The Hα absorption markings nevertheless still show an excess on the east side of the central meridian, and, it may be noted, these markings represent prominences of specially great density. The D_3 darkenings also preponderate east of the central meridian, and these likewise represent helium of unusual density.

There has been a great increase in the number of metallic prominences observed, and of prominences showing displaced lines. Increased solar activity is also indicated by the eruptive prominences, of which several have been observed or photographed at the Kashmir temporary observatory. One of these, observed on October 7, at latitude + 22° east, attained a height of nearly 7′, and was extraordinarily brilliant in the earlier stages. Photographs of eruptive prominences showing accelerating motion of ascent were obtained on October 30 at latitude + 28° east, and on November 1 at latitude − 62° east: the former ascended from 2′ 10″ to 4′ 40″

above the chromosphere with velocities increasing from 4 to 20 kilometres per second; the latter ascended from 4′ 20″ to 10′ 30″ with velocities increasing from 20 to 58 kilometres per second. This prominence exceeded in height any on our records. In the last plate of the series portions of it are visible at a height of nearly 11′. J. E.

Solar Research in 1915.

Solar Rotation.—A more extended investigation of the spectrographic solar rotation plates taken at Cambridge in June 1911 has been completed by J. B. Hubrecht (*M.N.*, lxxv. 611, and *Annals Sol. Phys. Obs. Camb.*, vol. iii. pt. 1). The results show a systematic diminution of the indicated velocity as the wave-length increases, which cannot be traced to instrumental errors and is considered to have its origin in the Sun itself. No evidence was found for special behaviour of any single line, or of any group of lines, of a given element, but it is noted that the atomic weights of the elements represented only ranged from 45 to 60. In relation to latitude, the results are symmetrical about the Sun's axis, but not with respect to the equator, the velocities of points in the northern hemisphere being in all cases greater than the corresponding points in the southern hemisphere. The deduced variation with latitude differs considerably from the Mount Wilson results for 1906–8, the most notable departures being a marked rise at 75° not found at Mount Wilson, and an equality from 0° to 15°.

The results of a very extensive research at Ottawa on the solar rotation by the spectrographic method have been given by J. S. Plaskett (*Ap. J.*, xlii. 373). No less than 834 spectra obtained in 1911, 1912, and 1913 were measured and reduced, the total number of lines measured being over 11,000, and of settings more than 120,000. A very high order of accuracy appears to have been attained, and the results generally confirm those obtained with the same instruments in 1911. The Ottawa observations indicate no variation in the rate of the solar rotation during the years 1910–1913 inclusive, and all the values are closely represented by the formulæ

$$V = (2{\cdot}006 - 0{\cdot}522 \sin^2\phi)\cos\phi$$
$$\xi = 14^\circ{\cdot}24 - 3^\circ{\cdot}71 \sin^2\phi.$$

The total range of mean velocity in each latitude, which is probably to be attributed to local movements in the reversing layer, was 0·04 km. per sec. The equatorial velocity of 2·006 km. agrees closely with the Allegheny value, but is lower than those of Upsala, Edinburgh, and Mount Wilson (average 2·06 km.), and higher than those of Cambridge and Kodaikánal (average about 1·9 km.). It is considered that while these differences are probably to be assigned to observational or instrumental errors,

and to personal differences in measurement, the Ottawa results may be entitled to special weight. No indication of any systematic differences of velocity for different lines or elements was given by the Ottawa plates.

Solar Radiation.—A paper of great interest, bearing the title "New Evidence on the Intensity of Solar Radiation outside the Atmosphere," has been published by Messrs. C. G. Abbot, F. E. Fowle, and L. B. Aldrich (*Smithson. Misc. Coll.*, vol. lxv., No. 4, June 1915). The authors reply to some of the objections which have been made in connection with their previous determinations of the solar constant, and give an account of their final piece of experimental evidence based upon pyrheliographic records at the highest altitudes to be reached by sounding balloons. A special form of the disc pyrheliometer was devised for the purpose, and the observers were fortunate enough to recover most of the records in good condition after the flights. The results are regarded as proving that the intensity of solar radiation, even at a height of 24 km. (15 miles), where the atmospheric pressure is reduced to 3 cm. of mercury, falls below 1·9 calories per square centimetre per minute. The general conclusion from the very numerous observations which have been made at various altitudes, and in widely different localities, is that "the solar constant of radiation is 1·93 calories per square centimetre per minute."

The Sun and Terrestrial Magnetism.—From a further discussion of the magnetic storms recorded at Stonyhurst in the period 1889–1913, Father Cortie finds additional support for his view that the efficiency of Sun-spots in relation to terrestrial magnetic disturbances depends upon the heliographic latitudes of the spots (*M.N.*, lxxvi. 15). The efficiency in general is found to diminish with increasing distance from the solar equator, but a specially active spot at a considerable distance from the equator may produce a disturbance in consequence of its influence not being restricted to one direction.

In continuation of his previously well-known work, E. W. Maunder has discussed the magnetic disturbances recorded at Greenwich during the years 1904–1913, in relation to the solar rotation (*M.N.*, lxxvi. 63). As for earlier years, the data indicate a strong tendency for disturbances to recur at intervals corresponding to the synodic rotation period of the Sun. Also, there is the same tendency of magnetic disturbances to occur when certain particular meridians are in the centre of the Sun's disc.

Solar Vortices.—Further important investigations of solar vortices have been made by Professor Hale (*Proc. Amer. Acad. Sci.*, i. 382). The typical spot-group consists of two spots of opposite magnetic polarity, lying in a direction nearly parallel to the Sun's equator. One of the spots may be replaced by several small ones, or by calcium and hydrogen flocculi, and the characteristic feature of the group is the presence of magnetic fields of opposite polarity in the regions including the eastern and western extremities. Observations of the Zeeman effects indicate the polarity, and hence

the direction of rotation of the electrons in the spot vortex. The direction of rotation of a "preceding" (western) spot vortex in the low latitude zone of the northern hemisphere is counter-clockwise, like that of a terrestrial tornado, while the opposite direction obtains in the southern hemisphere. In high latitudes the directions are reversed.

In another paper (*ibid.*, i. 385) Professor Hale and Mr. Luckey have shown that some of the phenomena of single and multiple spots can be closely imitated by simple laboratory experiments, which may also assist in explaining certain characteristic structures and motions of the solar atmosphere.

Electric Field of the Sun.—A preliminary attempt to measure the free electricity in the Sun's atmosphere has been made by Professor Hale and H. D. Babcock (*Proc. Amer. Acad. Sci.*, i. 123). Stark's discovery of the effect of an electric field on spectral radiation indicates a direct method of observation, which may ultimately furnish information as to solar electricity comparable with that given by the Zeeman effect with regard to solar magnetism. The preliminary investigation has shown that at the level of Sun-spots the electric field is probably of very low intensity. For the Sun as a whole, where the lines of electric force may be expected to be radial, observations of H_α and H_β near the limb indicated that the electric field-strength at the corresponding level was less than 200 volts per centimetre. It remains to be seen whether appreciable electric fields can be detected in solar eruptions, where the conditions for their production appear to be more favourable than in the quiet regions of the atmosphere.

The Chromosphere.—An important investigation of the spectrum of the chromosphere as photographed with the 60-foot tower telescope at Mount Wilson, without an eclipse, has been made by W. S. Adams and Miss Burwell (*Ap. J.*, xli. 116). The spectra apparently refer to a lower level of the Sun's atmosphere than that corresponding to Mitchell's eclipse spectra, and show a greater number of bright lines. Among other interesting results, it was found that a large number of faint cobalt lines are represented in the chromosphere, and that double reversal is probably characteristic of all low-level chromospheric lines. The dark-line spectrum at the Sun's limb also showed remarkable features, the intensities of many lines being greatly changed as compared with the ordinary solar spectrum, and several new lines appearing; there was also considerable evidence of the presence of a band spectrum, possibly identical with that of magnesium hydride, which is so prominent in the spectra of Sun-spots.

The Spectroheliograph.—A series of photographs of an interesting prominence, taken with the Rumford spectroheliograph at the Yerkes Observatory, 1914 October 19–21, have been described by O. J. Lee. From quiescence on October 20 the prominence became violently eruptive on October 21, and last appeared as a faint cloud, floating at an elevation of 430″, or 308,000 km. (*Ap. J.*, xli. 168).

A somewhat similar prominence, photographed at the Solar Physics Observatory, Cambridge, on 1915 April 19, has been described and illustrated by C. P. Butler. The general form of this prominence was that of an arch of about 30° span, as measured along the limb, the extreme height being 480″, or 216,100 miles. In less than an hour, all that remained were the two portions at the base. A strong group of flocculi was quite close to the limb at the same position angle as the brighter end of the large prominence (*M.N.*, lxxv. 554).

A new spectroheliograph of 13 feet focal length has been installed at the Mount Wilson Observatory, and has been used in conjunction with the 60-foot tower telescope. Some magnificent results in H_α have already been obtained by Professor Hale, including photographs taken at an interval of seven minutes, which show a marked stereoscopic effect (*The Observatory*, No. 496, p. 42).

Displacement of Solar Lines.—Further investigations of the displacements of solar lines have been made by J. Evershed and A. A. Narayana Ayyar, based upon direct comparisons of the iron arc and the centre of the Sun's disc (*Kod. Bull.*, xlvi.). The chief purpose was to determine if there was any evidence of a rising movement of the hotter vapours, as previously suggested by Mr. Evershed in explanation of the relatively great intensities of enhanced lines in the flash spectrum. Sixteen enhanced lines of iron were carefully measured on photographs taken with very high dispersion, but they gave no evidence of radial circulation of the corresponding vapours, nor of any relative movement compared with the arc lines. It is still possible, however, that the hotter ascending gases, which would account for the enhanced lines in eclipse spectra, give no appreciable absorption, while the enhanced absorption lines, in common with the arc lines, represent the falling gases. In that case each enhanced absorption line would have an emission line to the violet side, but it would be very difficult to detect. Further observations, to ascertain if there is a radial circulation of the solar gases, and whether the general movement of recession is radial to the Sun or radial to the Earth, are in progress.

With a view to detecting mutual displacements of closely adjacent solar lines, such as might be attributed to anomalous dispersion, Sebastian Albrecht has made an extensive comparison of Rowland's solar wave-lengths with the new standard wave-lengths of corresponding lines of iron as derived from laboratory observations. After eliminating the systematic shift of the Fraunhofer lines towards the red, it was found that lines with close companions on the red side were apparently shifted towards the violet, while lines with close companions on the violet side were shifted towards the red, the displacements varying with the distance between the lines. The results were regarded as favouring the view that anomalous dispersion produces measurable effects in the Sun's atmosphere.

Dr. Royds, however, is of opinion that the residuals between

Rowland's table and arc wave-lengths cannot be trusted to represent relative displacements, and has sought further evidence in direct comparisons of the Sun and arc (*Kod. Bull.*, xlviii.). He concludes that the relative shift between the two groups of solar lines having a close companion on one side or the other is too small to establish anomalous dispersion in the Sun. Dr. Royds' conclusion is supported by Mr. Evershed in a letter to *The Observatory* (No. 496). Evershed points out that, apart from the question of shifts, the existence in the solar spectrum of bands due to anomalous dispersion, or anomalous scattering, has never been demonstrated, and he challenges the advocates of anomalous dispersion in the Sun to produce evidence of these bands, in which the true absorption lines are supposed to be immersed.

The question of anomalous dispersion in the Sun has also been considered in great detail by Dr. St. John (*Ap. J.*, xli. 28). The general conclusion from this review of solar observations is that the deductions from the anomalous dispersion theory which are susceptible of definite and quantitative tests are not supported by the observational data, and that observations are outstanding which have not yet been explained by the theory.

An exhaustive investigation of the displacements of lines at the poles of an iron arc has been made by Dr. St. John and H. D. Babcock (*Ap. J.*, xlii. 431). The outcome is to show the necessity of considering the pole effect when the arc is used in comparisons of intensity, in the redetermination of wave-lengths, and in astrophysical investigations generally.

Studies of the tube-arc, and of strongly condensed sparks, carried on by A. S. King at the Mount Wilson laboratory, indicate that these sources impart an unsymmetrical structure to many of the stronger lines of iron, giving a displacement of the maximum, usually to the red. The results show that a condition of strong electrical excitation, combined with high vapour-density, produces a condition the displacing action of which shows many resemblances to the effects of pressure (*Ap. J.*, xli. 373).

Spectrum of the Corona.—R. Furuhjelm has found the wave-lengths 5303·38 and 4566·81 for two of the brighter coronal lines shown on photographs obtained by him during the eclipse of 1914 August 21 (*Nat.*, xcv. 353).

From measurements of displacement at opposite limbs of the Sun of the new red coronal line λ 6374·5, the equatorial velocity of the lower corona has been determined by J. Bosler as 3·9 km. per second. The photographs were taken during the eclipse of 1914 August 21, and the reference spectra were those of sunlight taken 10 minutes after totality. The deduced velocity is nearly double that of the photosphere, but it is not certainly real, because experiments have shown that in an ionised gas the luminous centres may have a velocity very different from that of the gaseous mass as a whole (*Comptes Rendus*, clx. 434). In a note accompanying this paper, Dr. Deslandres discusses the general problem of coronal rotation, and draws attention to the desirability

of substituting an artificial source for the Sun to give reference spectra.

A. Ricco (*Rend. della R. Accad. dei Lincei*, xxiv. 5) gives the mean wave-length of the new red zone of the spectrum of the corona, from a photograph obtained with small dispersion, as 6367, the more refrangible edge lying at 6363. These wave-lengths, as he states, lie within the three groups of lines from λ 6363·0 to λ 6643·9, as measured by Father Cortie. The coronal line in the green at λ 5303 is not shown on the photograph.

Miscellaneous.—The photo-mechanical method of detecting periodicities has been developed a stage further by A. E. Douglass. The new form of apparatus, now styled the "optical periodograph," has been applied in a preliminary way to the Sun-spot numbers, and to certain statistics of rainfall and tree-growth (*Ap. J.*, xli. 173).

A preliminary investigation relating to a possible systematic distribution in longitude of areas of solar activity has led Mr. Buss to conclude that there is a pronounced tendency for spot-outbreaks to occur in longitudinal spacings westwards, at intervals of somewhere near 60° or multiples thereof (*The Observatory*, Nos. 491, 493).

From a study of the Stonyhurst drawings for 1915, F. Henroteau shows the existence of convection currents in the faculæ (*M.N.*, lxxvi. 18). Their direction is polewards between ± 20° to ± 60°, and towards the Sun's equator in other heliographic latitudes.

A simple geometrical construction for determining the heliographic co-ordinates of Sun-spots has been given by F. Henroteau (*M.N.*, lxxv. 502).

A useful summary of some of the recent developments in solar physics is given in the report of a lecture by Professor Duffield on "The Meteorology of the Sun" (*Quart. Jour. Roy. Met. Soc.*, vol. xli., No. 175, July 1915). A. F.

Double Stars.

The abbreviations used are—

M.N.: Monthly Notices, Royal Astronomical Society.
A.N.: Astronomische Nachrichten.
A.J.: Astronomical Journal.
B.A.A.: Journal of the British Astronomical Association.
Ap.J.: Astrophysical Journal.
Ast. Soc. Pac.: Publications, Astronomical Society of the Pacific.

The *Transvaal Circular*, No. 24, contains measures of 310 southern double stars made at the Union Observatory with the 9-inch Grubb refractor in the years 1912–13–14. Mr. Innes adds to the value of these measures by giving in many cases previous

measures and notes. Incidentally some of Hussey's recent discoveries are identified with known doubles. About 190 stars in the 310 are under 2″ separation.

Circular No. 27 contains measures of 71 pairs by J. Voûte in 1915. Of these 56 are under 2″ separation, including Mr. Innes's second companion to η Argûs.

Mr. Voûte, in *M.N.*, 1915 March, has also measures made in 1913–14 at the Cape Observatory with the 7-inch refractor. The pairs, of which 49 are under 5″, have been measured with and without the reversion prism.

In *The Observatory*, 1915 May, Mr. Innes gives measures of the triple formed by *h* 3823 and Hussey 1339—AB (0″·7) AC (1″·8).

In the August number Mr. Innes announces a second companion to η Argûs—AC = 74°, 1″·0, and AB = 308°, 0″·8.

M.N., 1915 Nov., contains measures of α Centauri and γ Coronæ Australis in 1913 and 1915 by J. Tebbutt.

Measures of α Centauri in 1913–14, by E. H. Beattie, are in *B.A.A.*, 1915 February.

In *M.N.*, 1915 Jan., the Rev. T. E. Espin publishes measures of 59 new double stars (1294–1356), and a further list up to 1405 in the May number. These were found with the 17¾-inch and 24-inch reflectors at Tow Law. 68 are under 5″ separation.

The Rev. T. E. R. Phillips publishes measures made in 1914–15 with the 8-inch Coleman refractor belonging to the Society. Of these 55 are under 5″ separation and 10 over 5″.

η Cassiopeiæ	1914·65	250″·0	6°·64
ξ Bootis	1914·30	110·2	2·22

Mr. W. S. Franks, *M.N.*, 1915 Nov., gives a useful set of measures of 400 neglected pairs. These were made in 1915 with the 6½-inch refractor at Mr. F. Hanbury's Observatory, Brockhurst. Mr. Franks adds notes on colours.

Professor Doolittle, *M.N.*, 1915 June, publishes measures of 416 pairs made with the 18-inch refractor at the Flower Observatory. The stars include Aitken, Hussey, β and Σ pairs, 255 being under 5″ separation.

A.N., 4744. A set of measures of 93 wide pairs by M. Pavel with a 5-inch refractor at Breslau, and a further set made by Franz in 1899 and prepared for press by M. Pavel after the death of Franz. Five are under 5″ separation and 24 over 5″. Amongst these are Σ 73, η Cassiopeiæ, Castor, 61 Cygni.

Another set in *A.N.*, 4744, is by Dugan with the 23-inch Princeton refractor. Of these 22 are under 5″ separation and 11 over 5″ separation.

A.N., 4756, contains measures of 94 Struve pairs made at Bucharest by G. Demetrescu in 1913–14.

A.N., 4762. New double stars Roe (76–81) discovered with a 6½-inch refractor in the years 1912–14. Three are under 5″ separation.

In same number are measures of 62 southern pairs made with the 24-cm. refractor at the National Observatory at Santiago, by R. Grandon.

A.N., 4824, contains measures of Σ wide pairs made in 1915 by M. Luplau-Janssen.

A.N., 4823. "On the orbit of Σ 2026, by Martin Matzdorff, Strassburg. A period of 242 years is obtained, but there are large positive residuals from 1883 to 1912. Herr Wirtz, who sends the paper (1915 July), says that Herr Matzdorff was killed near Ypres 1914 Nov. 2.

A.N., 4769. Professor Seeliger has a note "Ueber das mehrfache Sternsystem ζ Cancri."

In *A.J.*, 675, F. P. Leavenworth gives measures made with the 40-inch Yerkes refractor in 1914. These are of stars in a selected list of very close pairs and pairs requiring remeasurement. 81 are under 2″ separation and 62 over 2″. A further set of measures made by F. P. Leavenworth in 1914, with the 10½-inch refractor of the University of Minnesota, is in *A.J.*, 678. Apparently these are from the same working list. There are 30 under 2″ separation and 27 over 2″.

Hough 212	1914·75	263°·7	0″·28
κ Pegasi	1914·73	152°·5	0″·16

A.J., 679–680, contains Professor Doolittle's measures of the earlier Jonckheere pairs. Some of the 106 pairs observed show motion.

Ast. Soc. Pac., 160. Professor Aitken gives measures of 41 Ophiuchi as a new pair, which he suspected of being double in 1905.

1914·54 298°·3 0″·52

Measures of α Cancri by Professors Barnard and Doolittle, in *Popular Astronomy*, 1915 Nov., prove that no change has taken place since 1836.

In the *Gazette Astronomique* (Société Astronomique d'Anvers), No. 83, are measures of Sirius and J 87 during the period 1910–1915. There is also a note on Σ 1134 and Σ 1143 by Mr. W. Franks.

In the *Astrophysical Journal*, 1915 April, Mr. F. Slocum gives the parallaxes of 4 visual binaries. These are deduced from photographic plates taken with the 40-inch Yerkes refractor.

	Period.	P.M.	Parallax.
42 Comæ	25·3 years	0″·49	0″·062
η Cor. Bor.	41·6 ,,	0·23	0·076
70 Ophiuchi	87·9 ,,	1·13	0·216
85 Pegasi	25·4 ,,	1·30	0·088

Parallaxes from photographs taken with the 26-inch McCormick refractor by Mitchell are also given in *Ap. J.*, 1915 October:

70 Ophiuchi (0″·165); Cygni 6, following (·051), and preceding star (·036).

The Observatory, 1915 Feb., contains an article by Mr. Lewis "On the Micrometer," and a note by Mr. W. S. Franks on "Σ 431 and o Persei," who points out the confusion which always exists in the nomenclature, and suggests that β 535 should be referred to as *omicron Persei* and Σ 431 as 40 *Persei*.

In the November number M. Jonckheere reviews recent work on double stars, viz. Aitken's work in vol. xii. of the Lick Publications; Doolittle's measures at the Flower Observatory, vol. iv. part i.; and Hussey's work at the La Plata Observatory, being vol. i. of the La Plata Publications.

In *The Observatory*, 1915 December, M. Jonckheere has a note on the nebulous star J 475 = B.D. −0°, 3630.

In *The Observatory*, 1916 January, is a précis of Dr. Aitken's paper in the *Proceedings of the National Academy of Sciences, Washington*, vol. i. part x. Dr. Aitken discusses the double stars under 5″ separation, and finds that

(1) As far as 9th mag. one star in 18 is visually double with the 36 inch.
(2) Visual double stars revolve in relatively small orbits, *i.e.* in every magnitude class there are more doubles under 1″ separation than with separation between 1″ and 2″, more between 1″ and 2″ than between 2″ and 3″, and so on.
(3) There are relatively more doubles in the Milky Way than in the remaining regions.
(4) Double stars show a marked preference for spectral types A and F. T. L.

Stellar Distribution and Drift.

Stellar Parallaxes.—In *Ap. J.*, xli. p. 237, F. Slocum gives the parallaxes of 4 visual binaries determined at Yerkes with the 40-inch refractor; and an account of the stellar parallax work now being carried on at the Leander McCormick Observatory is given by S. A. Mitchell in *Ap. J.*, xlii. p. 262. The preliminary results are given for two stars. The probable errors as determined from the internal agreement of the observations are small, but on the other hand the results for 70 Ophiuchi, which is common to both lists, are as follows: Slocum, +0″·212 ±0″·007; Mitchell, +0″·145 ±0″·007. In *M.N.*, *R.A.S.*, lxxv. p. 592, the parallaxes of 40 stars are given, determined at the Royal Observatory, Greenwich, this being the first instalment of the Greenwich determinations. The photographs were taken with the 26-inch refractor, and the stars on the programme are those with proper motions greater than 20″ per century, in the zone +65° to +90°. Brief announcements are given in *Pop. Astron.*, xxiii. p. 631, of parallax results communicated to the eighteenth meeting of

the American Astronomical Society. These include parallaxes of 9 stars determined by O. J. Lee and A. H. Joy with the Yerkes 40-inch refractor; 7 by S. A. Mitchell at Leander McCormick with the 26-inch Clark telescope; and 13 by A. van Maanen with the Mount Wilson 60-inch reflector, used as a Cassegrain with equivalent focal length of 80 feet. This last programme includes stars of types F and M of small proper motion.

R. Klumak in *A.N.*, cc., No. 4782, discusses the absolute motion of stars of well-determined parallax. He finds that it is impossible to represent the parallax stars by two streams whose centre of gravity is at rest, and that the very large velocities preponderate in Stream I. The large velocities are responsible for the increase in the amount of preferential motion with the magnitude of the stellar velocities. It is suggested that there exist groups of stars with large velocities moving in or nearly in the direction of preferential motion, and some possible groups are pointed out.

The Halley Lecture delivered by Sir F. W. Dyson at Oxford, 1915 May 20, on the "Measurement of the Distances of the Stars," and reprinted in the *Observatory*, xxxviii. pp. 249, 292, gives a concise account of the historical development in the methods of determining stellar parallaxes.

Proper Motions and Radial Velocities.—In *Ap. J.*, xli. p. 187, A. van Maanen gives a list of stars with proper motion exceeding $5''$ per century. The collection of known large proper motions in this way is very convenient for purposes of reference, although in the 533 stars given are included many whose proper motions are really much below the limit.

P. W. Merrill, *Ap. J.*, xli. p. 247, gives the radial velocities of 24 long-period variables of type Md, determined with the one-prism spectrograph attached to the $37\frac{1}{2}$-inch reflector of the Detroit Observatory. There is an unexplained discrepancy in the cases in which both bright and dark lines have been measured and the velocities separately deduced. The mean velocity relative to the Sun is 44 km. per sec.

W. S. Adams, *Ap. J.*, xlii. p. 172, gives the radial velocities of 500 stars, mainly of types A, B, or stars of small proper motion and magnitude between $5^{m}\cdot0$ and $6^{m}\cdot5$, determined at Mount Wilson. Interesting stars are A. Oe (N) 14320, velocity relative to Sun $+299$ km. per sec.; A. Oe (N) 20452, -170 km. per sec.; W. B $17^{h}\cdot514$, -131 km. per sec. Adams discusses these results, and concludes that stars of small proper motion show but a small progression of velocity with spectral type. The very distant stars of types F–M have small absolute velocities.

J. C. Kapteyn and W. S. Adams, *Proc. Nat. Acad. Sci.*, i. p. 14, discuss the relations between the proper motions and radial velocities of stars of types F-M. They find that the radial velocities show star-streaming very strongly, even in the case of the stars of smallest proper motion. The average radial velocities increase regularly with increase in proper motion, which may be due (1) to the velocities of the stars decreasing with their dis-

tance, (2) to the more luminous stars moving slower, or (3) to the existence of a correlation between the two motions so that Maxwell's law does not hold. Of these possible causes, there seems to be some evidence in favour of (2) and (3).

S. Oppenheim, *A.N.*, cci., No. 4822, applies some formulæ previously deduced for minor planets to stars of type B, supposing them to move parallel to a certain plane. Using the measured radial velocities he thus deduces a mean parallax 0″·0118, position of solar apex 266° 0′, + 34° 37′, and for the position of the Sun as it appears from the ideal centre of the B-type stars, 203° 55′, − 34° 9′.

K. W. Gyllenberg, *Lund Obs. Meddelande*, No. 65, discusses the absolute motion of 160 parallax stars, with parallax exceeding 0″·015, whose proper motions and radial velocities are known. The value of the solar velocity relative to the stars of each type is determined, giving in the mean a velocity of 20·60 km. per sec. towards 269°·3 + 29°·5. The distribution is represented approximately by an ellipsoid of revolution, flattened in the plane of the Milky Way, but there is no principal vertex.

C. A. Maney, *A.J.*, xxix., Nos. 679–680, discusses the system of the brighter A stars, using for this purpose 284 radial-velocity determinations.

The Star-Streams.—K. W. Gyllenberg, *Lund Obs. Meddelande*, ser. ii., No. 13, using radial-velocity measures, discusses by the correlation method the distribution of stellar velocities. He finds that the variation of the Sun's relative velocity with different spectral types is closely bound up with the value of Campbell's constant K. The velocity ellipsoids for the different types are found to be three-axial ellipsoids which are flattened perpendicular to the Milky Way, except in the case of the B stars. The eccentricity is largest for early-type stars and smallest for those of late types.

A. S. Eddington and W. E. Hartley, *M.N.*, *R.A.S.*, lxxv. p. 521, also discuss the radial-velocity determinations in relation to the systematic motions of the stars. The authors find a close agreement with the results obtained from discussions of proper-motions. The mean position for the vertex is given as 94°·6, + 12°·5, and the ratio of the axes of the velocity ellipsoid as 0·59. There is no evidence found of a progressive change with type of position of the vertex, although G stars give an anomalous result. Star-streaming is shown from the later A stars onwards.

H. Raymond, *A.J.*, xxix , No. 676, discusses by Schwarzschild's method the proper motions of Boss's *P.G.C.* in relation to spectral type. Results in general agreement with those derived in other investigations are obtained. The preferential motion is found to be stronger for the earlier-type stars, and within the earlier types for non-galactic stars. It is also markedly stronger for the large proper motions. The vertices of the various groups are found to lie on a band making a small but well-marked angle with the Galaxy.

S. D. Wicksel, *Lund Obs. Meddelande*, ser. ii., No. 12, using

the proper motions of Boss's *P.G.C.* for stars brighter than $6^{m}\cdot0$, discusses in great detail, by Charlier's method, the general characteristics of the frequency function. The velocity ellipsoid is found to have three unequal axes, the shortest of which is directed towards the galactic pole, and the longest to the galactic point $93^{\circ}+15^{\circ}$. The form of the ellipsoid is different from that derived by the discussion of radial velocities, in which the mean axis points towards the galactic pole. This is possibly due (1) to the mean parallax of the stars considered being greater near the pole of the Galaxy than in its plane, or (2) to a predominance of motion parallel to the galactic plane, or (3) to stars in the Galaxy having a smaller average velocity. The principal eccentricities are found to be very nearly independent of the assumptions made as to the density and luminosity laws.

R. Trümpler, *A.N.*, Bd. cc., No. 4790, discusses the relative motions of the Pleiades stars. The brighter stars have very small relative motions which are exceeded by the probable error of the determination, but those of the fainter stars are larger. These seem to move relatively to the brighter stars and to have a slow rotation completed in about two million years.

Spectral Type.—C. D. Perrine, *Ap. J.*, xli. p. 315, finds that for stars of type B the inherent velocities are, in general, a function of the apparent brightness and of the spectral subdivisions. The radial velocities are nearly zero for the brighter stars and for the earlier spectra. In *Ap. J.*, xli. p. 395, discussing stars of later type, he again finds a dependence of the inherent radial velocity upon magnitude. The highest velocities are found only amongst the fainter stars, and show a decided preference for the Milky Way. In *Ap. J.*, xli. p. 401, he shows that the largest number of great velocities and the greatest velocities occur amongst stars of types F and G, which are also nearest and have the largest velocities. Thus the average F, G stars, because they are nearest, appear brighter than the average of any other class of the same size and absolute luminosity. In *Ap. J.*, xlii. p. 304, the peculiarities of residual radial velocities of stars of different types are discussed in relation to the solar motion. The solar motion as derived from different spectral classes shows large and systematic variations in different regions of the sky, and also within the same spectral class. The chief cause of the discordance appears to be found in systematic or semi-systematic motions of the stars.

In *Observatory*, xxxviii. p. 392, A. S. Eddington discusses some of the results recently obtained by Kapteyn and Adams and by Perrine, and shows that, taken together, they indicate a progressive increase of speed with diminishing absolute brightness, which is an effect probably of greater range than the progression of speed with spectral type. He suggests that there may be a correlation between mass and speed from which the progression of speed both with type and with luminosity arise.

The *Observatory*, xxxviii. p. 379, contains the report of a discussion at the Manchester meeting of the British Association on

the spectral classification of stars and the order of stellar evolution, in which Fowler, Dyson, Eddington, Nicholson, and others took part. This forms a convenient résumé for purposes of reference of the pros and cons of Russell's theory of stellar evolution.

H. C. Plummer, *M.N.*, *R.A.S.*, lxxvi. p. 131, discusses the motions and distances of the bright stars of type F in the same way as stars of type A had been dealt with in an earlier investigation, and derives hypothetical parallaxes which compare in most cases favourably with those directly measured, where such comparison is possible. The mean absolute magnitudes are computed for different subdivisions of type, and it is found that from type F2 onwards the mean magnitude of stars with "peculiar" spectra is about 5^m on the average brighter than that of stars with "normal" spectra. This result has an evident bearing upon Russell's theory of stellar evolution.

Harlow Shapley, *Ap. J.*, xlii. p. 271, shows how, from the period and semi-duration of eclipse of an eclipsing binary, an upper limit to its density may be deduced. This result is applied to some binary systems of types G and K to prove the existence of such systems with densities very small compared with the density of the Sun. This evidence is strongly confirmatory of Russell's theory.

An account of some measurements of radiation received from stars made with a specially constructed sensitive thermo-element and galvanometer by W. W. Coblentz is given in *L. O. Bulletin*, No. 266. It was found that the radiation from red stars was two or three times as much as that from blue stars of the same photometric magnitude. Some idea of the spectral energy curves was obtained by measuring the energy transmitted by a water cell. From the measurements it is estimated that the total radiation from all the stars falling normally upon 1 sq. cm. of the earth's surface would raise the temperature of 1 gm. of water 1° C. in from 100 to 200 years. These measurements have been applied by Keivin Burns (*Pub. Ast. Soc. Pac.*, xxvii. p. 110) and by P. W. Merrill (*ibid.*, p. 120) to obtain some information as to the temperature of stars of different types. The evidence indicates a somewhat higher temperature for type A than for type B; but from type A to type M the mean temperature steadily decreases from about 8000° to about 2500°.

Distribution of the Stars.—H. Seeliger, *A.N.*, Bd. cci., No. 4801, discusses counts of stars down to 10^m and finds that the results are well represented by supposing that near the Sun and to a distance of 25 parsecs the stars are uniformly distributed, whilst beyond the density decreases according to the law $\rho^{-\lambda}$, where $\lambda = 0{\cdot}45$. These results are based upon the assumption of a flattened or "schematic" system. With certain assumptions as to the variation of λ with latitude, this result is shown to hold also when distances are measured from a point away from the Sun. Seeliger concludes that the schematic representation of the universe can throw but little light on what actually happens, and that formulæ found for

it are at best merely interpolation formulæ of mere formal significance and dangerous of application.

F. A. Lindemann, *M.N.*, *R.A.S.*, lxxv. p. 179, argues that Novæ must in most cases arise from collisions of dark stars, and deduces that there are 4000 dark stars to one bright star.

L. V. King, *Nature*, 1915 August 26, points out that the most recent estimates of the scattering of light in space require an amount of matter equivalent to about $1{\cdot}3 \times 10^6$ molecules of hydrogen per c.c. Although this seems so small, it means that in the cubic parsec there is a mass of dust which is 6300 times the mass of the Sun, whereas in the same volume the mass of lucid stars is not much more than 0·02 of the Sun's mass.

Stellar Dynamics.—A. S. Eddington in his second paper on this subject, *M.N.*, *R.A.S.*, lxxv. p. 366, discusses the dynamics of a system which possesses spherical symmetry and in which the distribution of velocities is everywhere according to Schwarzschild's law. He finds that it is possible to deduce a density law which does not give too great a congestion at the centre of the system, and which is thus in accordance with Turner's star-streaming hypothesis. The central density required cannot, however, be less than four times the density around the Sun. In a third paper, *M.N.*, *R.A.S.*, lxxvi. p. 37, systems are considered in which the restriction of spherical symmetry is not imposed, and which move under any conservative system of forces. The velocity ellipsoids define three orthogonal systems of surfaces which are called the *principal velocity surfaces*, and it is shown that for the general system, even though not in a steady state, these surfaces must be confocal quadrics. For a system moving only under its own attraction, the only possible solution is that of spherical symmetry, even when there is rotation. Prolate and oblate systems moving under controlling systems of force are discussed in detail.

J. H. Jeans, *M.N.*, *R.A.S.*, lxxvi. p. 70, has investigated whether it is possible to get a general theory of star-streaming. Very general results are obtained. Assuming any law of star-streaming, if this possesses no symmetry the universe must be spherical. If the law has one degree of symmetry, or is represented by a figure of revolution, the universe must also be a figure of revolution. If the law has two degrees of symmetry, or is spherical, then any shape is possible for the universe. He has further examined in which cases the dynamical conditions are satisfied, and concludes that a steady state is impossible with the conditions prevailing in our universe, so that star-streaming probably does not represent a steady state. H. S. J.

Astrographic Chart and Catalogue.

Two volumes of the Cape Astrographic Zones (ii. and iii.) were issued in 1915. Each of these contains the rectangular co-ordinates of 144 plates of a zone, the centres being at 42° S. and 43° S. decl.

respectively, which are treated as in vol. i., described in last year's report. The only other publication of the past year is vol. i. of the Vatican Observatory Astrographic Catalogue. The plates taken at the Vatican Observatory (the zone covers declination $+65^\circ$ to $+54^\circ$) are measured at Rome, but the reduction is being done at the Oxford University Observatory, and though the foreword and introduction to this volume are in Italian and are signed by Father Hagen, the later sections are in English and bear Professor Turner's name. This volume contains the measures of the plates whose centres are at declination $+64^\circ$, and therefore overlap the lowest plates of the Greenwich Zone. The measurement of the remainder of the plates taken at Rome is proceeding, and it is estimated that all will be finished in three years. Following the Astrographic Catalogue southward, the two zones next south of the Rome zone are undertaken by the Catania and Helsingfors Observatories respectively, and at these it is believed the Catalogue is proceeding. From Potsdam nothing has been issued for some years, but it appears from a recent report that the measurement has been advanced. The Oxford Zone which comes next in order is completed, and the remainder of the northen hemisphere is made up of the zones allotted to Paris and the French colonial observatories; where it is possible the work is proceeding.

As to the southern hemisphere, the polar cap as far as declination -51° is undertaken by the Melbourne and Sydney Observatories, and from these no recent report has been received. The state of the work of the Cape Zone (plate-centres -51° to -41°) may be inferred from the preceding paragraph. The measurement and reduction of the Catalogue plates with centres at declination -40° to -32° which are being taken at Perth (W. Australia), is being done both at that observatory and at the Royal Observatory, Edinburgh, and it is probable that the work is proceeding at San Fernando and Tacubaya. This hemisphere is completed by the zones -31° to -24° and -23° to -17°. The first of these has been undertaken by the Cordoba Observatory, and, writing early in last year, Professor Perrine said that all the Catalogue plates were taken and the measures well advanced. He estimated that in three years all the observations of comparison stars would be made and reduced, and all the plates measured.

The zone -23° to -17° is divided by the Santiago Observatory and the Nizamiah Observatory, Hyderabad. From a recent report of Mr. Pocock, Director at Hyderabad, it appears that regular work on the Catalogue was begun in December 1914, and that 111 plates have been measured and reduced.

The numbers of enlarged reproductions of chart plates received during the past twelve months are: Algiers 18, Bordeaux 44, Paris 10, Toulouse 10, which may be added to the numbers given in last year's report. H. P. H.

Observation of Meteors in 1915.

The following is a brief summary of some results obtained in England in regard to several of the more prominent meteoric displays during the year.

January Meteors:—

Cloudy weather and a full moon interfered with observations. A fine Quadrantid seen on 1914 Dec. 31 = ♀ at 11.14 by W.

March 5. A large fireball from Cygnus seen from the south of England.

March 28. A fireball from Virgo observed at various places with long flight over English Channel.

April Meteors:—

Only a few of these were noticed in 1915 on the 20th and 21st.

May Meteors:—

Several fine Aquarids of Halley's Comet seen by W. and M. Le Roy in the morning twilight of May 3 and 6.

July Meteors:—

The first Perseid seen on the 9th. W. observed quite a shower of them on 15th from 15° + 49°, and 2 good accordances were obtained with Bristol.

July 5. A large fireball from Virgo passed over the English Channel.

Very few of the July Aquarids were remarked. In recent years this shower seems to have become nearly extinct, though it formed a rich annual display from 1870 to 1908.

August Meteors:—

Aug. 10. W. recorded 20 meteors, radiant, 44½° + 57°.

Aug. 12. W. recorded 23 meteors, radiant, 47° + 57°.

Aug. 12. C. observed 30 meteors in 3 hours, including 26 Perseids, radiant, 46° + 57°.

Aug. 12. D. observed 68 Perseids in 3 hours, radiant, 47° + 58°.

Aug. 13. W. recorded 29 meteors, radiant, 49° + 58°.

Aug. 13. D. observed 29 Perseids in 2½ hours, radiant, 49° + 58°.

Aug. 14. C. observed 37 meteors in 2 hours, radiant of Perseids, 50° + 57°.

Aug. 14. W. recorded 11 meteors, radiant, 50° + 58°.

Aug. 13. $9^h\ 16^m$. Brilliant fireball passed over Scotland. Radiant in Ursa Minor.

The Perseids, which probably endure from June 26 to Sept. 5, according to recent investigations by D., returned with moderate intensity in 1915 (*Observatory*, 1915 Aug. and Sept.).

Sept. 5. Last Perseid seen by W. Path 94° + 67° to 96° + 69°, bright streak.

Mr. A. King found the radiant as follows:—

Aug. 10 = 44° + 56½°, 6 meteors.
Aug. 12 = 48° + 58½°, 14 meteors.
Aug. 13 = 48° + 58½°, 7 meteors.

Other Showers:—

1909–15 July 21–Aug. 15, 23° + 42°, 7 meteors, very swift.
1909–15 Aug. 10–13, 61° + 59°, 7 meteors, swift.
1903–15 Aug. 10–19, 61° + 47°, 7 meteors, bright and swift with streaks.
1900–15 July–Aug., 286° – 12°, 7 meteors, medium speed.

Many other observers witnessed the shower of Perseids, including the Rev. M. Davidson, Chigwell, Essex, Mr. F. Roberts, Hulme, Manchester, etc.

October Meteors:—

Oct. 5. Many meteors seen by W. 7½h to 12h and a brilliant fireball at 10.56 from a radiant at 248° + 72° and having a streak for 18 minutes (*B.A.A. Journal*, 1915 Oct.).

Oct. 13. Several small fireballs noted this evening. A very definite shower of slow meteors from a radiant at 13° + 5°, D.

Oct. 4. First Orionid seen by W., path 96½° + 25° to 101° + 30½°, rapid, streak.

Oct. 19. 16h to 17h. Shower of 8 Orionids recorded by W. from a good centre at 91° + 15° (*Knowledge*, 1916 Jan.).

November Meteors:—

Nov. 5. 17h 10m. First Leonid seen by W.

Nov. 14. 13½h to 16h. Shower of 6 Leonids seen by W. from 150° + 22°.

This return of the shower at a time when the parent comet is near Aphelion, and other displays in past years, clearly prove that the meteors are distributed completely around the cometary orbit (*Journal des Observateurs*, No. 2).

Nov. 17. Reported fall of a large aerolitic mass into the sea off San Salvador. It gave a loud detonation as it descended.

December Meteors:—

Dec. 11. 6½h – 12h. W. observed 37 meteors.
Dec. 12. 7¾h – 11h. W. observed 32 meteors.

About half of the total on the two nights were Geminids from a double radiant at 109° + 32° (11th) and 117° + 31° (12th).

Dec. 11. C. observed 9 meteors, including 5 Geminids, radiant, 108° + 32°.

Dec. 10 to 13. Mr. T. Hargreaves, Eton, recorded 40 meteors, including a number of Geminids, chiefly on 13th, from 111° + 30°.

Dec. 12. 16h to 18¼h. D. observed 27 meteors, including 18 Geminids, from 110° + 33° (12 meteors) and 118° + 32° (6 meteors).

Dec. 15. 16½h to 18¼h. D. observed 13 meteors; no Geminids.

The shower appears to have exhibited moderate intensity in 1915, and the double radiant, detected in previous years, was very obvious.

During 1915 the real paths of 86 fireballs and shooting stars were computed, and these results, incorporated with others obtained in 1912, 1913, and 1914, have already been published (*Monthly Notices*, vol. lxxvi. p. 219). W. F. D.

Abbreviations :—

W., Mrs. Fiammetta Wilson. D., W. F. Denning.
C., Miss A. Grace Cook.

Stellar Spectroscopy in 1915.

Nebulæ.—The year 1915 is noteworthy for the increase of our knowledge of the motions of the nebulæ, and this increase is in the main due to the activity of the Pacific observers.

The observers at the Lick Observatory have been specially active, having secured more than 200 measures relating to 61 nebulæ. A brief summary of results relating to 54 nebulæ with bright lines is communicated by W. W. Campbell (*Proc. Nat. Acad. Wash.*, **1**, 8):

Velocities km/sec	0–10	10–20	20–40	40–60	60–80	80 and more
Number of nebulæ	11	6	17	11	2	7
Average velocity	5	16	28	50	77	132

The average velocity for the 54 nebulæ is 42 km/sec or seven times that of the helium stars, all the above results having been freed from the effect of the Sun's motion. The algebraic mean, after correcting for the Sun's motion, is −2 km/sec. Two of the nebulæ which are less than 3° apart, viz. N.G.C. 6644 and N.G.C.$_2$ 4732, have velocities +202 km/sec and −141 km/sec.

In a second communication (*Proc. N.A. Wash.*, **1**, 496) W. W. Campbell and J. H. Moore announce that 348 measures relating to 92 gaseous nebulæ are now available. Freed from the effects of the solar motion, the average velocities are:

of 7 extended nebulæ . . 10 km/sec.
of 73 planetary or regular form 39 ,,

of 34 stellar less than 5″ diam. . . 50 km/sec.
39 non-stellar (disks and rings) . 29 ,,

73

These 73 nebulæ exhibit the phenomena of star-streaming, and have motions which are characteristic of the stars, as shown by the value of the solar motion derived from them, 20·1 km/sec.

Examination of the nebulæ in the Magellanic Clouds by R. E. Wilson (*Proc. N.A. Wash.*, **1**, 183, 498) shows that 11 nebulæ in the greater Cloud have velocities between +237 and +287 km/sec, whilst the only known nebula in the lesser cloud has a velocity of +149 km/sec. It would be interesting to attempt by

long exposures to get signs of the continuous spectrum of these objects, with a view to detecting possible characteristics of novæ.

The radial velocities of six nebulæ are published by F. G. Pease (*A.S. Pac.*, **27**, 239): the Dumb-bell −63 km/sec; Messier 33, −278 km/sec; N.G.C. 7023, +0·7 km/sec; N.G.C. 6572, −12 km/sec; N.G.C. 6826, −8 km/sec; N.G.C. 6891, +38 km/sec.

The radial velocity of the Andromeda nebula has been determined by F. G. Pease (*A. S. Pac.*, **27**, 134). The result, −329 km/sec, is in agreement with earlier measures by Wolf, Wright, and Slipher. The velocity of N.G.C. 1068 is also announced by F. G. Pease (*A.S. Pac.*, **27**, 133). The result, +765 km/sec, is considerably lower than Slipher's value, +1100; whilst the measures of J. H. Moore (*A. S. Pac.*, **27**, 192) give the value +910, which is nearly the mean of those just given.

Spectrographic observations of the planetary nebula N.G.C. 7009 have disclosed to W. W. Campbell and J. H. Moore (*A.S. Pac.*, **27**, 245) unmistakable signs of rotation.

Special spectrographic observations of the Orion nebula have been made by E. B. Frost (*Proc. N.A. Wash.*, **1**, 416) for the purpose of confirming by the spectrographic method the variation in the radial velocity detected by Bourget, Fabry, and Buisson by interferometric methods. For several points around the trapezium, and not more than 2′ away from it, velocities were found to range between +6 and +17 km/sec.

Two valuable notes by W. H. Wright (*Proc. N.A. Wash.*, **1**, 266, 416) deal with proposals for a system of classifying nebulæ by means of their spectra.

Novæ.—The spectrum of Nova Geminorum No. 2 has been photographed at Mount Wilson as late as April 1915 by W. S. Adams and F. G. Pease (*Proc. N.A. Wash.*, **1**, 391). It has now developed into that of a Wolf-Rayet star, being essentially identical with that of Nova Persei (1901) in 1913. The same writers announce (*A.S. Pac.*, **27**, 237) that the spectrum of Nova Lacertæ is also developing into the Wolf-Rayet type. It was photographed with an exposure of 16 hours in September 1915, when the magnitude of the star was found to be 13·5.

Special Studies. — The spectrum of the irregular variable η Carinæ has been further studied by R. F. Sanford (*L.O.B.*, viii. 134).

The spectrum of the faint companion of Sirius has been photographed at Mount Wilson by W. S. Adams (*A. S. Pac.*, **27**, 236). It is found to be similar to that of Sirius. The suggestion has been made that the light of the companion is due to light reflected from Sirius, but Adams points out that o_2 Eridani presents a similar case of a star of very low intrinsic brightness with a spectrum of the type of A0.

A brief note on the spectrum of stars of Harvard types N and R by W. S. Adams is published in *A.S. Pac.*, **27**, 238. Mrs. Fleming distinguished the type R from the type N on the ground that the violet portion of the continuous spectrum was much more intense in type R.

Specially sensitive thermocouples have been designed and made by W. W. Coblentz (*L.O.B.*, viii. 104), who has used them in radiometric measurements of 110 stars with the Crossley reflector at the Lick Observatory, with very interesting results. His observations are discussed by K. Burns (*A.S. Pac.*, **27**, 110) and by P. W. Merrill (*A.S. Pac.*, **27**, 120).

A study of the distribution of energy in the spectrum of the integrated light of the globular cluster Messier 3 has been carried out by E. Hertzsprung (*Ap. J.*, **41**, 10). By comparison with neighbouring stars, the distribution appears to be very nearly like that of a typical F star.

The effective wave-lengths of 184 stars in the cluster N.G.C. 1647 have been determined at Mount Wilson by E. Hertzsprung (*Ap. J.*, **42**, 92). A coarse grating was made by stretching rubber cords 3 mm. thick, separated by free spaces of the same width, over the end of the tube of the 60-inch reflector. The distance between the two spectra of the first order gives a measure of the effective wave-length.

Similar appliances were also used by E. Hertzsprung (*Ap. J.*, **42**, 111) in determining the effective wave-lengths of stars of very low luminosity.

Classification of Stellar Spectra.—A very interesting account of the work of the Henry Draper Memorial is given by Miss Cannon in the *Journal of the R.A.S. of Canada*, June 1915, 203–215, illustrated by many photographic plates. From it we learn that the New Draper Catalogue of stellar spectra approaches completion. The classification has proceeded at the rate of 5000 stars per month since January 1912, and is completed for the northern stars and nearly as far as 18*h* for the southern. On 1915 April 17 Miss Cannon was able to state that 199,196 spectra had been classified, and about 150,000 had been identified, the data being collected in a card catalogue in order of right ascension. It was then expected that the catalogue would be finished in six months, and that printing might be started soon after that time.

The Annual of the Bureau des Longitudes, 1915, contains an article by A. de Grammont on stellar spectra and their classification, with a table showing the correspondence of various recent methods of classification.

Sir N. Lockyer devotes the first four numbers of the *Hill Observatory Bulletin* to notes on stellar classification. Bulletin No. 3 contains a catalogue of 354 of the fainter stars (apparent magnitudes, $3\frac{1}{2}$–$5\frac{1}{2}$).

A full report of the discussion at the Manchester meeting of the British Association on spectral classification of stars and the order of stellar evolution appears in *The Observatory*, 1915, 379–392.

Notes on the densities of second-type stars are published by H. Shapley (*Proc. N.A. Wash.*, **1**, 459, and *Ap. J.*, **42**, 271).

Distribution of Stellar Spectra in Space.—The highly interesting development of the intricate relations between spectral distri-

bution, absolute luminosity, transverse proper motions, radial velocities, and star-streaming is well illustrated by the following papers :—

1. J. C. Kapteyn and W. S. Adams (*Proc. Nat. Acad. Wash.*, **1**, 14) on the relation between proper motion and radial velocities of stars of types F, G, K, M.
2. W. S. Adams (*Ap. J.*, **42**, 172) on the radial velocities of 500 stars.
3. C. D. Perrine (*Ap. J.*, **41**, 315) on the apparent dependence of radial velocities and proper motions upon magnitudes and spectral sub-divisions of the stars within class B.
4. C. D. Perrine (*Ap. J.*, **41**, 395) on the relation between radial velocities of the stars and their [apparent] magnitudes.
5. A. S. Eddington and W. E. Hartley (*M.N.*, **75**, 521) on a determination of the systematic motions of the stars from the radial velocities.
6. S. D. Wicksell (*Lund Medd.*, ser. 11, No. 12) on the general characteristics of the frequency function of stellar movements as derived from the proper motions of the stars.
7. W. Gyllenberg (*Lund Medd.*, ser. 11. No. 13) on stellar velocity distribution as derived from observations in the line of sight.

It is hardly possible to give an adequate terse summary of the tendency of all this important work. An admirable introduction is available in the summary given by A. S. Eddington in *The Observatory*, 1915 October, p. 392. The position is therein freed from technical details, and the outstanding uncertainties are clearly set forth. The many-sided attack promises soon to disclose answers to the questions—

Is there a relation between velocity and distance from the centre of the stellar system?

Is there a relation between velocity and absolute luminosity?

How far from the centre of our system does star-streaming extend?

Is there correlation between radial and transverse motion, of a kind to diminish the weight set upon transverse motion as an indication of distance?

Radial Velocities.—The results of recent determinations at Mount Wilson of the radial velocities of 500 stars are published by W. S. Adams (*Ap. J.*, **42**, 172). The list includes:

1. A- and B-type stars chosen as likely to throw light upon the study of the elements of the two principal star streams.

2. A, F, G, K, and M stars, which have only very small astronomical proper motions, and, being chiefly of apparent magnitude between 5 and 6·5, may in general be considered as distant stars of high luminosity.
3. Stars with measured parallax, mostly with large proper motions and of magnitudes between 5 and 8·5. (One hundred others stars from this category have already been published in an earlier list (*Ap. J.*, **39**, 341).)

The list of velocities is accompanied by a careful and highly interesting discussion of the results, which should serve to show whether the differences between the velocities for stars of different spectral classes are less marked when the stars have been selected as being probably very distant, than when they have been selected according to apparent magnitude, as in Campbell's early survey. In the early survey there is no doubt that stars of solar type are moving more rapidly than stars of types A and B. Adams's work is a first attempt to solve the question whether there exists any such marked difference for the stars of the solar type with distances comparable with those of types A and B. He finds—

i. Among the very distant stars observed at Mount Wilson the change of radial velocity with spectral type is slight. Low average velocities are found for distant stars of types F to M.
ii. Campbell's results point to the same conclusion when allowance is made for the relatively near stars among his F to M spectra.
iii. The Mount Wilson stars, when arranged in two groups of small and of large proper motion, show even more marked change of velocity with spectral type than Campbell's mixed stars disclosed in their average values.
iv. Stars of low absolute luminosity have extraordinarily great radial velocity. Even excluding such as have velocities greater than 100 km/sec, the average is 36 km/sec for 16 stars of measured parallax, 8 of them having velocities exceeding 40 km/sec.

The radial velocities of 24 long-period variable stars of class Md, determined at the Detroit Observatory, are published by P. W. Merrill (*Ap. J.*, **41**, 247).

Three stars with unusually large velocities +114, −148, −179 km/sec are announced by W. S. Adams (*A.S. Pac.*, **27**, 132).

Variable Radial Velocities.—Observations made by the D. O. Mills Expedition disclose variable velocities in 14 stars, a list of which is given by R. E. Wilson (*L.O.B.*, viii. 124).

The spectra of the stars γ Aquarii (A2) and σ Leonis (A) have been measured by J. B. Cannon, but no satisfactory periods have been found for either star, and accordingly measures only are published (*Ottawa Obs.*, **1**, 409, 433).

Spectroscopic Binary Stars.—Orbits are given for the following stars :—

				P.	*e.*
ϵ Volantis (B5)	Sanford	*L.O.B.*,	viii. 127	$14^d{\cdot}168$	0·0
ν Ceutauri (B2)	Wilson	,,	viii. 130	2·625	0·0
υ Sagittarii (B8p)	,,	,,	viii. 132	137·939	0·08
$41\upsilon_4$ Eridani (B9)	Paddock	,,	viii. 168	5·010	0·01
108 Herculis (A3)	Daniel & Jenkins	*Alleg. Obs.*,	iii. 147	5·515	0·0
25 Serpentis (B8)	Jordan	,,	iii. 153	38·95	0·77
λ Tauri (B3)	Schlesinger	,,	iii. 167	34·60	0·0
VV Orionis (B2)	Daniel	,,	iii. 179	1·485	0·0
θ_2 Tauri (A5)	Plaskett	*Ottawa Obs.*,	ii. 63	140·7	0·72
β Coronæ Bor. (Fp)	Cannon	,,	i. 375	40·9	0·4
136 Tauri (A)	,,	,,	ii. 105	5·969	0·02
ζ Andromedæ (K)	,,	,,	ii. 143	17·767	0·04
ω Cassiopeiæ (B9)	Young	,,	ii. 89	69·9	0·30
25 Cassiopeiæ (B8)	,,	,,	ii. 181	33·75	0·41
50 Draconis (A)	Harper	,,	ii. 123	4·120	0·02
1149 Groombridge (A5)	,,	,,	ii. 167	9·944	0·08

A third body has been found to be involved in λ Tauri by F. Schlesinger (*Alleg. Obs.*, iii. 167), giving an oscillation of period $3^d{\cdot}95$ in the main (eclipsing) period of $34^d{\cdot}6$.

In the system of VV Orionis a slow oscillation of 120 days has been detected by L. Daniel (*Alleg. Obs.*, iii. 179).

In a short note C. D. Perrine calls attention to interesting characteristics of spectroscopic binary stars of class M (*Ap. J.*, **42**, 370).

A tabulation of spectroscopic binaries (omitting Cepheids) is given by F. C. Jordan (*Alleg. Obs.*, iii. 159), arranged in four groups, Oe5 to B8, Ao to A5, Fo to F8, and G to M, each group in order of duration of period. The sudden change of eccentricity is clearly indicated.

"Contributions to the Statistics of Spectroscopic Binary Stars" is the title of a short summary (in English) by S. Wicksell (*Ark. Mat. Stockholm Acad.*, **10**, No. 6).

The spectroscopic binary star δ Orionis (period $5^d{\cdot}7325$) is found by J. Stebbins (*Ap. J.*, **42**, 133) to be an eclipsing variable, with two minima in agreement with the spectroscopic orbit.

Seven new spectroscopic binary stars are announced by W. S. Adams (*A.S. Pac.*, **27**, 132).

Work in the Laboratory.—An attempt to detect relative displacements of the spectral lines seen in a luminous source of mixed elements has been made by E. G. Bilham (*Ap. J.*, **42**, 469), who has compared the wave-lengths of iron and calcium lines in a carbon arc under different conditions.

The variability of spectrum lines in the iron arc has been

studied in detail by C. E. St. John and H. D. Babcock (*Proc. Nat. Acad. Wash.*, **1**, 131). The examination shows that the wave-lengths of many lines depend on the portion of the arc used as source of light. Out of 1600 lines examined, 1300 lines exhibit constancy and about 300 show variability ranging between +0·025 and −0·030 ångströms.

The dissymmetry of lines in tube-arc and spark spectra is being investigated by A. S. King (*Proc. N.A.W.*, **1**, 371).

The pole effect in the iron arc has been studied by C. E. St. John and H. D. Babcock (*Ap. J.*, **42**, 231).

The relative intensities of corresponding lines in the iron spectrum as observed in the arc and the oxyhydrogen flame are given by Sir N. Lockyer and H. E. Goodson (*Proc. R.S.*, **92**, 260).

The band spectrum associated with helium has been shown by A. Fowler (*Proc. R.S.*, **91**, 208) to contain series which can be represented by formulæ involving the Rydberg constant. This interesting new departure has also been studied by J. W. Nicholson (*Proc. R.S.*, **91**, 432).

The origin of the 4686 series has been tested by interferometer methods by T. R. Merton (*Proc. R.S.*, **91**, 382), who attributes it to an atom having a mass about one-tenth of the mass of the hydrogen atom.

Observations of the "grund spectra" of alkali metals have been made by E. H. Nelthorpe (*Ap. J.*, **41**, 16).

The most persistent lines (*Raies ultimes*) in the spectrum of an element have been studied by A. de Grammont (*Ann. Chem.*, iii., 1915), who suggests a relation between such lines and the maximum in the distribution of energy in line spectra.

Instruments.—Sir N. Lockyer (*Hill. Obs. Bull.*, No. 3) describes the installation of the McClean twin telescope, with apertures 12 and 10 inches, which carries the objective prism of 20°.

The remodelling of the 60 feet tower telescope of the Mount Wilson Observatory is described by G. E. Hale (*A.S.P.*, **27**, 233).

The progress of the 100-inch reflector of the Mount Wilson Observatory is recorded by the same writer (*A.S.P.*, **27**, 235).

The utilisation of objective prisms for determinations of radial velocity is developed by Hamy (*C.R.*, **161**, 661).

A new and ingenious form of reflecting collimator to be used with a reflector of large aperture is described by P. Fox (*A. and Ap. Soc. of Amer.*, **2**, 112).

Reductions.—A paper on spectroscopic orbit formulæ for single and double spectra and small eccentricity is published by G. F. Paddock (*L.O.B.*, viii. 153).

Attention is called by W. W. Campbell (*A.S.P.*, **27**, 129) to an error in radial-velocity determination arising from non-uniform illumination of the slit, and R. K. Young (*A.S.P.*, **27**, 183) describes a case in illustration. H. F. N.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

The Dominion of Canada.
His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The Board of Education.
The French Ministry of Public Instruction.
The Portuguese Minister of Public Instruction.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Institution of Electrical Engineers.
London, University College.
Meteorological Office.
Napier Tercentenary Committee.
National Physical Laboratory.
Physical Society of London.
Royal Institution of Great Britain.
Royal Observatory, Greenwich.
Royal Photographic Society of Great Britain.
Royal Society of London.
Cambridge Observatory.
Cambridge Philosophical Society.
Cambridge University, Solar Physics Observatory.
Chatham, Royal Engineers' Institute.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Edinburgh, Royal Observatory.
Edinburgh, Royal Society.
Leeds Astronomical Society.
Manchester Astronomical Society.
Manchester Literary and Philosophical Society.
Oxford, Radcliffe Observatory.
Oxford, University Observatory.
Salcombe Regis, Hill Observatory.
Stonyhurst College Observatory.
Abbadia, Observatoire.
Algiers, Observatoire.
Allegheny Observatory.
Amsterdam, Koninklijke Akademie van Wetenschappen.
Antwerp, Société d'Astronomie.
Arcetri, Reale Osservatorio.
Astronomical and Astrophysical Society of America.
Barcelona, Sociedad Astronómica.
Basel, Naturforschende Gesellschaft.
Batavia, Koninklijke Natuurkundige Vereeniging.
Batavia, Royal Magnetical and Meteorological Observatory.

Berlin, Königlich Astronomisches Recheninstitut.
Bombay and Alibag, Government Observatories.
Bordeaux, Observatoire.
Bordeaux, Société des Sciences Physiques et Naturelles
Boston, American Academy of Arts and Sciences.
Calcutta, Astronomical Society of India.
Canada, Royal Society.
Cape of Good Hope, Royal Observatory.
Cape Town, Royal Society of South Africa.
Cape Town, South African Association for the Advancement of Science.
Catania, Reale Osservatorio.
Catania, Società degli Spettroscopisti Italiani.
Chicago, Society for Practical Astronomy.
Cincinnati Observatory.
Copenhagen, Kongelige Danske Videnskabernes Selskab.
Copenhagen, Observatorium.
Detroit Observatory.
Egypt, Survey Department.
Geneva, Observatoire.
Geneva, Société de Physique et d'Histoire Naturelle.
Genoa, Istituto Idrografico.
Granada, Observatorio Astronómico, Geodinamico y Meteorológico.
Groningen, Astronomical Laboratory.
Halifax, Nova Scotian Institute of Science.
Harvard College Astronomical Observatory.
Helsingfors, Finska Vetenskaps Societet.
Helwân Observatory.
Hobart, Royal Society of Tasmania.
Hyderabad, Nizamiah Observatory.
India, United Service Institution.
India, Survey Department.
Japan, Astronomical Society.
Johannesburg, Union Observatory.
Kodaikánal and Madras Observatories.
Leiden, Sternwarte.
Lick Observatory.
Lisbon, Observatorio Astronomico.
Lowell Observatory.
Lund, Astronomiska Observatorium.
Madrid, Observatorio Astronomico.
Mauritius, Royal Alfred Observatory.
Milan, Reale Osservatorio di Brera.
Montpellier, Académie des Sciences et Lettres.
Mount Wilson, Solar Observatory.
Northfield, Minn., Goodsell Observatory of Carleton College.
Oporto, Academia Polytechnica.
Ottawa, Dominion Astronomical Observatory.
Palermo, Reale Osservatorio.

Paris, Académie des Sciences.
Paris, Bureau des Longitudes.
Paris, Bureau International des Poids et Mesures.
Paris, Dépôt Général de la Marine.
Paris, Observatoire.
Paris, Observatoire de la Société Astronomique de France.
Paris, Société Astronomique de France.
Paris, Société Mathématique de France.
Paris, Université.
Perth Observatory, Western Australia.
Perth, Western Australian Astronomical Society.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Philadelphia, University of Pennsylvania.
Pomona College Astronomical Society.
Potsdam, Central Bureau der Internationalen Erdmessung.
Princeton University Observatory.
Pulkovo, Observatoire Central Nicolas.
Rio de Janeiro, Observatorio.
Rome, Reale Accademia dei Lincei.
Rome, Specola Astronomica Vaticana.
San Fernando, Instituto y Observatorio de Marina.
San Francisco, Astronomical Society of the Pacific.
Stockholm, Kongliga Svenska Vetenskaps-Akademie.
Sydney, Royal Society of New South Wales.
Tacubaya, Observatorio Astronómico Nacional.
Tokyo Observatory.
Toronto, Royal Canadian Institute.
Toronto, Royal Astronomical Society of Canada.
Tortosa, Observatorio del Ebro.
Toulouse, Académie des Sciences.
Toulouse, Observatoire Astronomique.
Turin, Reale Accademia delle Scienze.
Turin, Reale Osservatorio di Pino Torinese.
Turin, Società Astronomica Italiana.
Turin, Società Urania.
Washington, National Academy of Sciences.
Washington, Carnegie Institution.
Washington, Navy Department.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Yerkes Observatory.
Zi-Ka-Wei, Observatoire Astronomique de Zô-Sè.
Zürich, Naturforschende Gesellschaft.
Zürich, Schweizerisch Geodätische Kommission.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."

Editors of the "Astrophysical Journal."
Editor of the "Athenæum."
Editor of Brown's Nautical Almanac.
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."
Editor of "Knowledge."
Editor of "Nature."
Editors of "The Observatory."
Editors of "Popular Astronomy."
Editors of "Terrestrial Magnetism."

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Sigr. G. Boccardi.
Prof. E. W. Brown.
M. F. De Roy.
Dr. A. M. W. Downing.
Dr. J. L. E. Dreyer.
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ADDRESS

Delivered by the President, Professor R. A. Sampson, M.A., D.Sc., F.R.S., on presenting the Gold Medal of the Society to Dr. J. L. E. Dreyer.

The Council has decided to award the Gold Medal to Dr. J. L. E. Dreyer, of the observatory of Armagh, for his contributions to Astronomical History and for his Catalogues of Nebulæ. In laying the grounds of this award before the Society, I shall take the second matter first.

Dr. Dreyer, as we all know, is a Dane by birth. After his student years at the University of Copenhagen he became attached to the observatory of the Earl of Rosse. The six-foot mirror had always been devoted chiefly to the nebulæ, and Mr. Dreyer, besides observing himself, published in 1878, in the *Transactions of the Royal Irish Academy*, a Supplement to Sir John Herschel's General Catalogue, with a copious list of corrections, and further prepared for publication the whole series of observations of nebulæ with the great reflector from 1848 to 1878, covering the work of a sequence of well-known observers, including G. Johnstone Stoney, R. S. Ball, R. Copeland, and Mr. Dreyer himself. This important work was published by Lord Rosse in 1880, in vol. ii. of the *Transactions of the Royal Dublin Society*. By this time Mr. Dreyer had become an assistant at Dunsink Observatory, and observations of nebulæ were interrupted, to be resumed later when he became astronomer at Armagh. The resources of the observatory of Armagh had at this time been injuriously affected by the operation of new legislation, and Government was induced to grant some compensation. This permitted the purchase of a 10-inch refractor, and Mr. Dreyer resumed his work upon nebulæ with it. He examined them to settle questions of identity, to refute assertions that had been made as to their variability,* and to determine the personal equation affecting transits of these objects,† and published also observations with the filar micrometer of one hundred of them.‡ But his most notable work, as well as the one by which his name is everywhere known, is the New General Catalogue.§ This was not originally presented in the form that is now so familiar. It was offered to our Society as a supplement and revision of three previous independent catalogues; that is to say, Sir John Herschel's General Catalogue, those of D'Arrest and Lord Rosse, to which may be added Dr. Dreyer's own revision of the first, which I have mentioned above. Acting, however, upon a suggestion from the Council, and feeling that the simultaneous use of so many works was inconvenient, he undertook to recast it, and to embody the whole of the recorded observations in a single catalogue. It comprised, when completed, 7840 entries, each entry representing a critical examination of the

* *M.N.*, vol. xlvii. p. 412.
† *M.N.*, vol. lvii. p. 44.
‡ *Roy. Irish Acad. Trans.*, 1894.
§ *Mem. R.A.S.*, vol. xlix.

existing documentary material. It was published in 1888, and has remained ever since an indispensable work of reference to the observatory. It is too well known to make necessary any extended description, nor does it lend itself to one. One point only I will mention. Dr. Dreyer, to his regret, found himself obliged to replace the index numbers of the Herschels by a sequence of his own. The fact that the N.G.C. reference-number has now quite driven any other reference from the field, speaks for itself as to the general acceptance of the work as a standard.

A catalogue of nebulæ and clusters has a more permanent character than a catalogue of double stars, the additions being fewer and there being no changes to record. Nevertheless, Dr. Dreyer has found it necessary to follow his New General Catalogue of 1888 with two supplementary catalogues,* upon the same lines, of new nebulæ discovered up to the year 1907, comprising 5386 objects; and later, returning to the earlier work in connection with the papers of Sir William Herschel, of which I shall speak below, he revised Herschel's three catalogues by the help of the original observations upon which they were founded, and in the light of modern observations of the same objects.

While astronomer at Dunsink Mr. Dreyer engaged with Ralph Copeland in a project of another kind. The journal *Astronomische Nachrichten* has seen a good many ups and downs, and about the year 1880 Copeland and Dreyer felt that there was room for another organ. They started one in the following year upon somewhat the same international and general lines as the elder journal. Originally it was called by the pleasant name *Urania*, but this, it turned out, was already the property of some astrological sheet, so it was renamed *Copernicus*, and under that name it appeared for three years. By this time circumstances had changed; in America Gould's *Astronomical Journal* had been revived, in France the *Bulletin astronomique* had come into existence, and in Germany a new editor, Krüger, had vastly improved the old *Astronomische Nachrichten*. So *Copernicus* had to give way; but in its short course it had given utterance to several interesting papers, among which may be mentioned three by Dr. Dreyer himself. The first (*Copernicus*, i. p. 134) deals with the ancient astronomical instruments at Pekin. Most people suppose that all that was of merit in these, apart from magnificent workmanship, was due to the Jesuit Father Verbiest in the seventeenth century. Dr. Dreyer, having had photographs sent to him, and with the help of some rather obscure descriptions, was able to make clear that the earlier instruments which Verbiest somewhat unceremoniously dismissed were in reality almost identical with his own, though made four centuries earlier, and that the Chinese in the thirteenth century had an equatorial construction for their armillæ which it was counted one of the greatest reforms of Tycho Brahe in the sixteenth century to introduce, in place of the inconvenient and unsymmetrical zodiacal armillæ inherited

* *Mem. R.A.S.*, vols. li., lix.

from Ptolemy.* A second paper (*Copernicus*, iii. p. 104) shows Dr. Dreyer in one of his favourite rôles—a picker-up of rare but unconsidered astronomical books, in this case a pamphlet, attributed to L. Euler, on the multiple tail of the comet of 1744. The observation which it recorded was due to "einem geschickten Frauenzimmer"—a clever woman,—and with the aid of this somewhat slender clue and of his own *nous* Dr. Dreyer succeeded in identifying both the observation and the clever woman in the meteorological diary kept for many years by the Kirch family, now one of the MSS. at the Royal Observatory, Edinburgh. I think it right to mention these small but interesting matters, because in the award of the Medal we consider a man's work as a whole, and the tool-play of the craftsman and his temper of mind are shown as plainly in lesser matters as in greater. But the third paper (*Copernicus*, ii. p. 135) which I would mention is of an important character, namely, a determination of the Constant of Precession. Newcomb observes, in his moderate way, in his "Astronomical Constants," that the determination of the Constant of Precession is "somewhat difficult," because the right ascensions of the numerous smaller stars which it is safe to use are not themselves determined fundamentally, but by reference to a less numerous group of fundamental stars with which they are connected through an obscure magnitude equation; these again are not determined directly but by reference to the Sun, and the zero of the Sun's right ascension can only be found by considering its declination. Had he written the passage to-day, he would have added that the degree to which star-drift enters and gives a systematic bent to the proper motions of the stars employed must also be most carefully considered. It is none the less somewhat surprising to find how few are the classical determinations of this fundamental constant. Newcomb, who was a careful reader and may be said to have missed nothing, brings four into account in his "Astronomical Constants" (1895),† namely, those of Ludwig Struve, Nyrén, Bolte, and the work of our Medallist to which I am now referring. In vol. viii. of the *Astronomical Papers of the American Ephemeris* (1897),‡ where Newcomb obtains his definitive determination, he embodies Dr. Dreyer's result with only very slight revision in the light of subsequent knowledge, making an exception in his procedure in order to do so. It is therefore apparent that Newcomb had thoroughly considered this memoir and attached unusual value to it. The occasion for writing it was to scrutinise a surprising result of Nyrén's, by which it appeared that the Constant of Precession came out at a distinctly lower value when derived from a group of stars of magnitude fainter than had been previously employed. Dr. Dreyer, after a very careful, critical, and historical

* I learn further from Dr. Dreyer that there is every probability that the armillæ of 1279 were not after all devised by the Chinese themselves, but were due to a Persian savant, Gemal-Ed-Din, who is known to have visited Pekin at that period. *Cf.* Tycho Brahe, *Opera Omnia*, t. i. p. xviii.

† P. 126. ‡ Pp. 11, 61.

survey of the previous determinations, shows that ground for qualifying Nyrén's result may be found in his own material, and proceeds to make a fresh determination from faint stars, being upwards of 3000 in number, that were common to the catalogues of Lalande and Schjellerup, the epochs of which are separated by sixty-six years. I need not insist that such an undertaking requires the highest degree of skill, knowledge, and industry, and I believe that no higher encomium could be passed upon the result than Newcomb's mature and reiterated acceptance of it.

I come now to Dr. Dreyer's contributions to Astronomical History. Exactly sixty years have elapsed since the only other occasion when the Medal was awarded for historical work, the recipient on that occasion being Robert Grant, and the work honoured his History of Physical Astronomy. The only other name in our list of Medallists which is connected with valuable historical work is that of Schiaparelli, and he had, shall I say the mischance, to receive the Medal when still a comparatively young man, for his demonstration of the connection of comets and meteor swarms, while much of the best work by which we remember him was undone, and in particular his learned and illuminating essays unwritten—"I Precursori di Copernico nell' Antichità" (1873), and "Le Sfere Omocentriche di Eudosso, di Calippo et di Aristotele" (1875), *Pubb. d. R. Osserv. di Brera in Milano*, iii., ix.—which would otherwise certainly have received mention. On the occasion of the award to Robert Grant the President, Manuel Johnson, devoted space and attention to showing that an award for historical work was not inconsistent with the laws or unwritten intentions of the Society. I shall not follow him upon this ground. It is unnecessary, because the precedent has been established. But in any case, I should prefer to confine myself to a description of what our Medallist has done, trusting to the work to justify itself if I succeed in representing it to you in its true perspective.

I imagine that one reason why an award of the Medal upon historical grounds is so rare is that original workers in this region are so few. Much has been written upon astronomical history, but the greater bulk of it hardly professes a complete scrutiny of the sources, still less a competent judgment upon them. Besides Schiaparelli, whose historical work after all was merely learned bye-play, one recollects the name of Rudolf Wolf of Zurich, who never wearied in unearthing out-of-the-way original documents, especially such as related to Swiss names. I would class with works of this rank Ideler's *Handbuch der Chronologie*; but passing by many valuable and thorough discussions of isolated points, I suppose one must go back to the great Delambre, always interesting because himself always interested, before one comes to anything really solid and satisfying. One realises that the best work has been very well done, and it is in the rank of the best work that in my judgment we must place the contributions of Dr. Dreyer. His first book, published in 1890, is entitled *Tycho Brahe: A Picture of Scientific Life and Work in the Sixteenth Century*. In

the preface he tells us: "Although not a few monographs have been published from time to time to elucidate various phases in the career of Tycho Brahe, while several popular accounts of his life (by Helfrecht, Brewster, etc.) have appeared, the only scientific biography hitherto published is that of Gassendi." This sentence orients the judicious reader at once, for Gassendi was acquainted with pupils of Tycho, and wrote in Latin 250 years ago. One realises at once that a distinct opportunity offered for a good piece of historical work, but one which only a learned man could have found, and a very learned man could take advantage of. At the same time this reference to Gassendi seems to me to have a psychological interest. The man of to-day sees Gassendi as if he were still a living factor. He approves or disapproves what Gassendi has written, and consciously measures himself by him as a standard. In this way a man of historical tastes has the faculty of annulling time, of living among what people and circumstances he likes, and of finding a not unsatisfying companionship in the past and even in the future, where he might easily feel pretty lonely in the present. But while we are speaking of this comparison with Gassendi, we must not press the similarity too far. Dr. Dreyer's reference set me to read some part of Gassendi's book which I had never opened before, and while it is a remarkably live and interesting work and free from the pedantry that disfigures so much scientific writing, old and new, I should not call it a scientific biography in the modern sense. The necessary documents for one were not accessible. Dr. Dreyer's own task was a very different one. His materials are voluminous and diffuse. In the sixteenth century means of communication were difficult; persistence, however, made up for much, what with writing of long letters to friends and obliterating enemies in controversial pamphlets. As a consequence, around a personage like Tycho almost the whole scientific interests in Europe, that is to say, in the world, may be grouped. Astronomy was the only science worthy the name, but astronomy had not yet disengaged its hand from that of astrology. It was a twilight time,—a time that possessed Copernicus *De Revolutionibus*, without seeing what a revolution of another kind that book imported. It had seen the Reformation, but not its back-lash in the Thirty Years' War. The New World in the West hardly as yet occupied it at all. It is a picture of this time that Dr. Dreyer has to get upon his canvas, and he is a hardy man that would attempt it.

When Dr. Dreyer was young there is reason to believe that, like other young men, he scalped his literary enemies for choice. There is a pamphlet in the library of the Royal Observatory, Edinburgh, in which Dr. Dreyer deals with the pretensions of another author to write Tycho's life. The pamphlet is in Danish, but it begins with a passage which I shall read as it stands, because the poorest Danish scholar can follow it. "'. . . . An abstruse subject, I should conceive,' said Mr. Pickwick. 'Very, sir,' responded Pott, looking intensely sage. 'He crammed for it; to use a

technical but expressive term, he read up for the subject, at my desire, in the *Encyclopædia Britannica*. . . . . He read for metaphysics under the letter M, and for China under the letter C, and combined the information, sir!'" Such were Mr. Dreyer's controversial methods at the age of nineteen. Youth will seldom consent to screen the light even when its glare is rather cruel. Years have made him gentler if not less direct. He writes now in a plain style, that is unpolemical, without *parti pris*, and wholly free from affectation. It repays careful reading, for then you will notice that every word is chosen. He writes at length, for indeed you cannot write history in summary; it is not that you miss the point of events, it is their inconsequence that escapes you. Had Tycho behaved with common prudence, probably he need never have left Denmark. Had he never left Denmark, his observations would probably never have come into Kepler's hands. The more one looks into the details of history, the more difficult it is to draw any moral from them. One is often reminded of Carlyle's comment on Browning's *The Ring and The Book*, that it was "all made out of an Old Bailey story that only wanted forgetting." Details are interesting, though, and if that is their only charter, it is a sufficient one.

Information is so defective or so conflicting that we always require to know all there is to say; and out of Dr. Dreyer's many careful strokes an image emerges of Tycho's impressive and romantic figure, as clear but no clearer than the documents justify. We see the great observer, the first who realised the bigness of his task, and who met it with equally big preparation. We like him perhaps the better for not shining remarkably in theory, because it throws into a purer light his special vocation, and there is no vocation we moderns honour more than that of the pure observer.*

Dr. Dreyer's next work, published in 1906, was the *History of Planetary Systems from Thales to Kepler*. In the preface Dr. Dreyer tells us his reasons for writing this book:—"What chiefly induced me to write this book was the circumstance that a number of legends on subjects connected with the history of the cosmical systems have been repeated time after time, not only in works on the general history of science and literature like those of Hallam and Draper, but also in books dealing specially with astronomy. Among errors long ago refuted but still frequently produced in print may be mentioned: that Thales knew the earth to be a sphere; that Pythagoras and his school taught the motion of the earth round the Sun; that Plato taught the daily rotation of the earth, and in his old age inclined to the heliocentric system; that the Egyptians knew that Mercury and Venus move round the Sun; that the lunar variation was discovered by Abu'l Wefa; that King Alfonso the X of Castille found the orbit of Mercury to be an ellipse (which has not been refuted before, so far as I know), and

* In one of the notes appended to his book Dr. Dreyer shows that if correct allowance is made for refraction the probable errors of Tycho's places of standard stars are $\pm 24''$ in R.A. and $\pm 26''$ in Dec.,—a truly wonderful result.

that Cusa and Regiomontanus anticipated Copernicus. On the other hand, some writers are inclined to belittle the knowledge of the ancients, making out that Plato imagined the earth to be a cube, and that the spheres of Eudoxus and the Ptolemaic and Tychonic systems are impossible and absurd."

This long list of current errors gives one pause. It is to be feared that history as it is written and received must be an unedifying spectacle to the student of original documents. In the preface to his *L'île des pingouins* Anatole France gives an ironical account of the difficulties that beset a writer of history, in particular the choice he must make between becoming a palæographer pure and simple, who confines himself to publishing the documents, and, on the other hand, writing a descriptive history which shall show the motives and inner springs that actuate events. He lays his intention of doing the latter before an accomplished professor of that school. "A quoi bon, mon pauvre monsieur," replies the historian, "vous donner tant de peine, et pourquoi composer une histoire, quand vous n'avez que copier les plus connues, comme c'est l'usage? Si vous avez une vue nouvelle, une idée originale, si vous présentez les hommes et les choses dans un aspect inattendu, vous surprendrez le lecteur. Et le lecteur n'aime pas à être surpris. Il ne cherche jamais dans une histoire que les sottises qu'il sait déjà. Si vous essayez de l'instruire vous ne ferez que l'humilier et le fâcher. Ne tentez pas de l'éclairer, il criera que vous insultez à ses croyances."

We need not admit that the position is quite so desperate as these words convey, but it is clear that a fresh recension of all the originals for Dr. Dreyer's book was a formidable task. At the present day we enjoy a confidence—which is perhaps not sufficiently conscious of the limitation of its title—that we can understand Nature, and require only to use more and more diligence and care upon lines well established. In antiquity and in the Middle Ages it was not so. Motions, essences, influences were involved in the same mist. Not unnaturally, human destiny bulked largely in the view, and seemed no more obscure than the rest, while the language that had to cope with this confusion had not yet subsided into conventional grooves but must rely upon its own suggestiveness to evoke ideas that did not exist. The smoky lamp of knowledge was handed in turn from the Chaldæans to the Egyptians and to the Greeks, from the Greeks to the Arabs, from the Arabs to Europe. The ground has been worked in parts many times, but that did not always make it easier for a new labourer. It made the material more voluminous, without in all cases leaving it less obscure. Dr. Dreyer handles it all with obvious ease. Each page of his book represents his own judgment and his own research. We have exact references for each statement, and, finally, he shows a sympathy that one admires in interpreting the efforts of the ancients to express themselves, whether these convey what they knew or what they could not know.

In the year 1910, when our Society, in collaboration with the

Royal Society, undertook a publication of Sir William Herschel's *Collected Works* (1912), we were fortunate to be able to enlist the assistance of Dr. Dreyer upon the editing committee. The chief weight of the work fell upon his shoulders; he contributed to it notes upon Herschel's three catalogues of nebulæ, in which references are given to modern comparisons, and the MS. originals in the possession of the Royal Society, as well as observing journals, were read through. He also wrote the "Short Account of Sir William Herschel's Life and Work, chiefly from Unpublished Sources," which precedes the papers. In this he has brought to light for the first time many interesting particulars; for example, as to the methods and strokes devised by Herschel for polishing his mirrors, which were carefully preserved secrets at the time, and dissipates, we need not be surprised to find, some hoary fictions; thus the story that Herschel was a deserter from the Hanoverian army is laid to rest, one hopes for ever, by printing the text of his discharge for the position of a hautboist, who had *treu und ehrlich gedienet.*

As soon as the work upon planetary systems was off his hand, Dr. Dreyer returned to Tycho. He had for many years made a collection of publications bearing upon him. In 1908 he began preparations for a complete edition of his observations, under the auspices of the Carlsberg Institute. Later, through the munificence of a Danish gentleman, Mr. Hagemann, the scope was extended to an edition of all Tycho's works, acts, and letters, drawn from manuscript as well as printed sources. This work is now in course of publication by the Danish Society of Language and Literature; two sumptuous volumes have been issued, and it is expected that thirteen or fourteen will be required to complete it. For the purpose of collating the manuscripts, of which the bulk is great, certain Danish scholars are associated with Dr. Dreyer, otherwise he is responsible for the whole text, notes, and introductory memoir, which has been translated into Latin. When this work is completed it will unquestionably be of unique value to scholars, recording from the sources themselves all the acts of a life so full, so central, and human as that of Tycho, in a period that is, I suppose, by no means exhausted.

I trust that these words, in which I have endeavoured to represent Dr. Dreyer's work in its plain light, will amply justify to the Society the award which the Council has made.

Addressing Dr. Dreyer, the President said:—

Dr. Dreyer, we would not rob Denmark of you, but you have so long been one of us that we feel we have absorbed you, speech and person. We have watched with admiration your labours, carried on for so many years in circumstances of some isolation from your brother astronomers, and recognise in them love of truth and unaffected learning. We trust that, with good health, they may be long continued, and that this Medal which I hand you may stand for the token of the value which astronomers set upon them.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President.

R. A. Sampson, Esq., M.A., D.Sc., F.R.S., Astronomer Royal for Scotland.

Vice-Presidents.

Sir F. W. Dyson, M.A., LL.D., F.R.S., Astronomer Royal.
Col. E. H. Hills, C.M.G., D.Sc., F.R.S.
W. H. Maw, Esq., LL.D.
H. F. Newall, Esq., M.A., D.Sc., F.R.S., Professor of Astrophysics, Cambridge.

Treasurer.

E. B. Knobel, Esq.

Secretaries.

A. S. Eddington, Esq., M.A., M.Sc., F.R.S., Plumian Professor of Astronomy, Cambridge.
Alfred Fowler, Esq., F.R.S., Professor of Astrophysics, Imperial College of Science and Technology.

Foreign Secretary.

Arthur Schuster, Esq., Sc.D., Ph.D., Sec. R.S.

Council.

Sydney Chapman, Esq., M.A., D.Sc.
Rev. A. L. Cortie, S.J.
A. C. D. Crommelin, Esq., B.A., D.Sc.
J. W. L. Glaisher, Esq., Sc.D., F.R.S.
Walter Heath, Esq., M.A.
J. H. Jeans, Esq., M.A., F.R.S.
H. S. Jones, Esq., M.A., B.Sc.
E. W. Maunder, Esq.
J. W. Nicholson, Esq., M.A., D.Sc., Professor of Mathematics, King's College.
Rev. T. E. R. Phillips, M.A.
A. A. Rambaut, Esq., M.A., D.Sc., F.R.S., Radcliffe Observer.
H. H. Turner, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.